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THE ALL-UNION CONFERENCE OF STEEL MELTERS

M. A. Pertsev

Translated from Metallurg, No. 10, pp. 1-2,
October, 1960

From August 23 to August 26 the All-Union Conference of Steel Melters was held in Stalino, more than 600 specialists taking part—representatives of steel plants and research institutes in the Soviet Union, leading scientists, production innovators, Heroes of Socialist Labor and workers of the Central Institutions.

About 100 reports were discussed, dealing with various problems in steel melting production. Of considerable interest was the discussion of the general state and further possibilities for development in Soviet steel melting production. The conference approved the trends decided in the last few years for the development of steel production, the main points being:

1. Increasing the fraction of large furnaces by building new furnaces, increasing the capacity of existing furnaces and scrapping low capacity obsolete units.

2. Further introduction of rapid methods of steel melting, using oxygen and air, using new types of refractories, improving the preparation of the charge— metal scrap, iron and fluxes.

3. Increasing the production of steel in oxygen converters and electric furnaces.

4. Introducing vacuum melting processes, the use in electric furnaces of molten iron instead of solid iron, converting phosphorus irons in converters, the development and operation of new, more efficient designs of furnaces and new methods for operating the main sections of steel melting departments.

5. Further automation in processes, using computers to control steel melting units.

6. Equipping the steel melting departments with more powerful and improved equipment and improving the mechanisms of those sections still using manual labor.

The conference was divided into three sections— open-hearth, electric melting and converter.

The open-hearth section concentrated on the intensification of smelting as the main source of increasing steel melting at existing furnaces.

The use of oxygen for the intensification of melting can increase the output of furnaces at the best plants by 20% and more. The steel workers of the "Zaporozhstal'" Plant and the Nizhne-Tagil Combine, operating with oxygen, have increased the average yield of steel from 1 m^2 of hearth area to 10 tons. However, even at these leading plants there are still large unused reserves of production which can be utilized by improving the methods for using oxygen. Feeding oxygen directly into the bath of the open-hearth furnaces during the melting and finishing periods, which is now the practice at the Makeev Plant, can double the effectiveness of oxygen compared with feeding it into the spray. This method of operation should find extensive application.

The conference noted the necessity for the extensive building of oxygen stations at steel plants, considering it the most important condition for increasing steel melting within the next few years.

The delegates exchanged experience on the firing of open-hearth furnaces with cold natural gas and coke oven gas. Of special interest is work with cold gas in the new large-capacity furnaces of the Magnitogorsk Combine and in one of the furnaces of the "Azovstal'" Plant. Improved designs of these units, in particular the

increased hearth area can give a higher output than firing with a mixture of coke oven and blast furnace gases. All possibilities must be used in redesigning existing furnaces and converting them to operation with cold gas.

It was pointed out that the output of open-hearth furnaces should be increased by increasing the weight of a heat (converting furnaces to double charge) with the simultaneous conversion to operation with all-welded ladles and more powerful ladle cranes.

Recommendations were accepted for the main parameters of furnaces with 600-700 and 800-900-ton charges.

The conference decided that decisive measures should be taken to improve the preparation of raw materials for steel smelting production, the low level of development of which is now holding up the intensification of the melting process. In the first place powerful presses must be produced to compress the scrap; also enrichment and lumping of the ore with simultaneous fluxing (especially at the Ukrainian plants); the quality of the iron must be improved, in particular its sulfur content should be reduced and there should be a sharp reduction in the fluctuations in silicon content. At plants where the quality of iron cannot be improved in the blast furnace due to the quality of the blast furnace raw material, the iron must be treated outside the blast furnace.

The delegates stressed the fact that the quality of open-hearth refractories must be improved since existing refractories do not fulfil the new requirements for operation with oxygen intensification. In the first place the production of dense highly calcined refractories for the working spaces of open-hearth furnaces should be expanded.

The conference discussed problems in the automation of open-hearth operation. The system used at the Nizhne-Tagil furnaces was approved. The hope was expressed that in the near future the experience of various plants on the automation of open-hearth furnaces would be generalized so that the best systems could be selected.

There were discussions on increasing the yield of useful steel by reducing the amount cut from the tops of ingots; this can be done by improving the heating of the ingot tops and by the production of semikilled steels. The delegates emphasized the necessity of speeding up the introduction of continuous casting of steel.

The reports of workers from the steel plants were interesting. The head of the Central Factory Laboratory of the Magnitogorsk Combine, N. M. Selivanov, reported on experience in the operation of a new design of high-capacity open-hearth furnace and on experience in melting and using low-sulfur conversion iron with a constant content of impurities.

A foreman from the Kuznets Combine, Gurskikh, reported on the operation of open-hearth furnaces at the Combine and on the remote control of steel pouring. Shvetsov, a steel worker of the Taganrog Steel Plant and Hero of Socialist Labor, dealt with experience in operating open-hearth furnaces with natural gas.

In the electric steel melting section there was a discussion on problems of selecting the most efficient methods for vacuum melting of steel outside the furnace. Those taking an active part in the discussion were A. M. Samarin, Corresponding Member of the Academy of Sciences, USSR, Dr. M. V. Pridantsev, Director of the Institute of High-Quality Metallurgy of the Central Research Institute for Ferrous Metallurgy, Dr. G. N. Oiks and Dr. N. M. Chuiko.

Much time was devoted to a discussion of the operation and design faults of new 80-ton electric furnaces. B. V. Barvinskii gave an interesting lecture on this problem.

The section noted the large program of work on the development of complex devices for the mechanization of operations in electric steel melting production and the automatic control of the melting and pouring of metal.

Of the new advanced processes special mention was made of the treatment of metal with synthetic molten slags in the ladle, developed by the Central Research Institute for Ferrous Metallurgy together with the Zlatoustovsk Steel Plant, and also the melting of special high-duty steels and alloys in induction and arc vacuum-electric furnaces and by the method of electro-slag remelting, developed by the Paton Kiev Institute of Electrowelding together with the "Dneprospetsstal' " Plant.

The section recommended that steel concerns should extensively adopt the treatment of metal by synthetic slags in steel melting production. Recommendations were also made for the use of various high-quality refractories for lining electric furnaces.

The delegates in the converter section pointed out the extreme importance of developing converter production, which will involve less capital investment compared with open-hearth production yet will increase the capacity of steel-melting production within short periods.

The section members discussed the operation of the converter departments of the Petrovskii Plant and the V. I. Lenin Krivoi Rog Plant and underlined the remarkable achievements of these departments in converter productivity. One converter of the Petrovskii Plant now produces in one year more steel than the open-hearth furnace at the "Azovstal' " Plant.

The section also considered problems in the selection of best methods for the conversion of vanadium chrome nickel and phosphorus irons. The section was of the unanimous opinion that a converter department should be built at the "Azovstal' " Plant and not an open-hearth department.

Measures were put forward for improving the automation of converter production and speeding up the development of 200-250-ton converters.

There was a lively discussion on measures for improving the durability of the converter linings. The section considered it essential to organize the production of cheap tar-dolomite refractories. The work of the section was brisk; the exchange of ideas on problems of improving converter production will undoubtedly be very useful.

The recommendations produced by the All-Union Conference of Steel Melters will play an important part in the further development of steel melting production in our country and in the fulfilment by steel workers of the resolutions drawn up by the Plenum of the Central Committee of the Communist Party of the Soviet Union on the vigorous intensification of technical progress and increase in labor productivity.

CHOOSING THE FURNACES AND THE FUEL FOR MAGNETIZING ROASTING OF KRIVOI ROG QUARTZITES

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Institute for Gas Utilization of the Academy of Sciences, Ukrainian SSR

Translated from Metallurg, No. 10, pp. 3-7,
October, 1960

The method of magnetic concentration cannot be used for oxidized and semi-oxidized iron ores. Such ores can be concentrated by flotation; also they can be subjected to a magnetizing roast and subsequently to magnetic concentration. The question of the development of a rational concentration method for such ores assumes particular significance, as the cheap ores from the Lisakovsk and Kerch deposits and also the Krivoi Rog quartzites must now be mined.

An analysis of technical and economic data for the flotation and the magnetizing-roasting-concentration processes at the Anshansk Metallurgical Combine shows that the flotation concentrate is cheaper than the magnetizing-roasting concentrate, its iron content is higher and tailing losses are lower. On the other hand laboratory testing yields a better concentrate in the case of magnetizing roasting. When the correct choice of furnace and fuel is made for the magnetizing-roasting concentration the capital requirements and operating costs can be lowered substantially and the process may be made economical.

At present two types of furnaces are used for the magnetizing roasting: 1) rotary kilns of "Lurgi" type (Fig. 1); 2) shaft furnaces of the Anshansk type (Fig. 2).

The "Lurgi" rotary kilns, 50 m long and 3.6 m in diameter, were used for roasting Salzhuette iron ores. Capacity of these kilns was 900 tons per day and the fuel consumption was 4.5-6% of the ore weight. The kilns

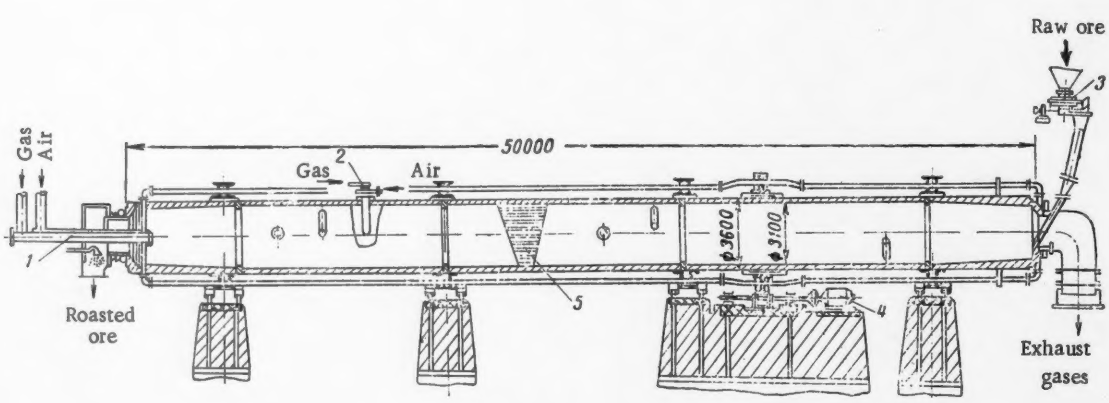

Fig. 1. "Lurgi" rotary furnace. 1) Front burner; 2) peripheral burner; 3) ore feeder; 4) furnace drive; 5) tumbling vanes.

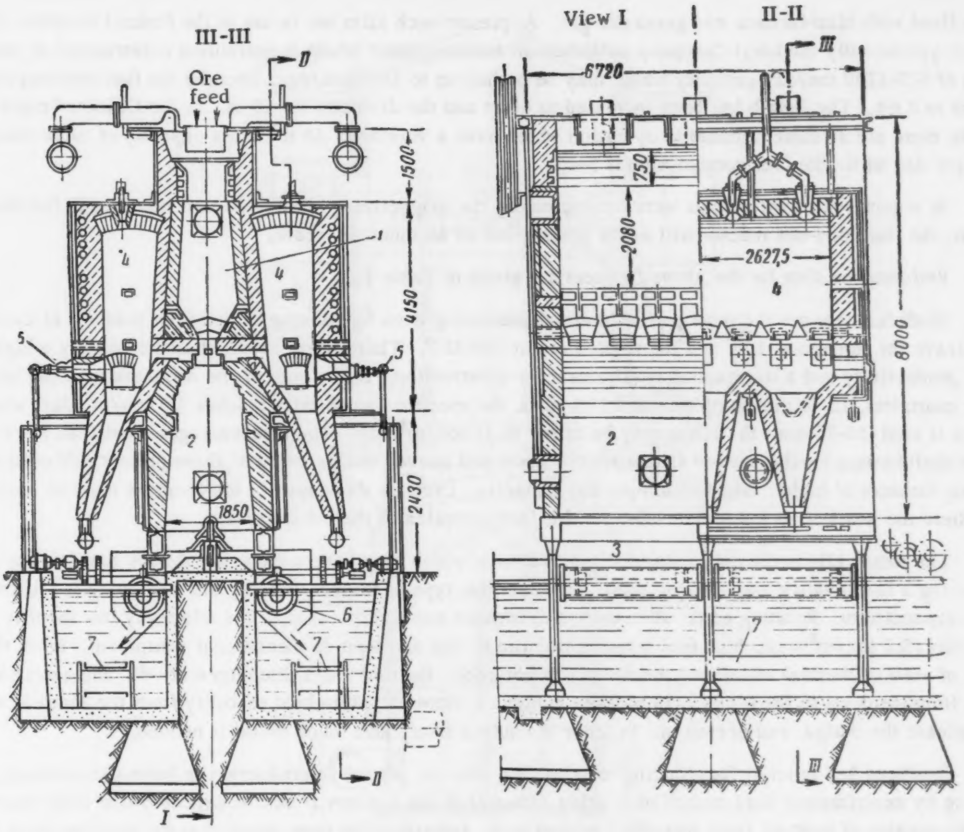

Fig. 2. The Anshansk shaft furnace. 1) Ore-preheating zone; 2) reduction zone; 3) cooling zone; 4) combustion chamber; 5) burner; 6) feeder; 7) apron feeder.

TABLE 1. Technical and Economic Indices of Roasting Furnaces

Furnace	Dimensions, m: length (height)	Dimensions, m: diameter (width)	particle size, mm	Capacity: ton/day	Capacity: ton/m^3·day	specific fuel consumption, %	Roasting quality: % Fe concentrate	Roasting quality: % Fe tailings	Roasting quality: recovery, %	Approximate cost (in millions)
Shaft	8.0	1.3×5.25	12–75	300–400	5.5–7.3	3.0–4.0	58–60	12–16	70–75	0.4–0,5 rubles
Rotary	50	3.1	<25	900–1100	2.4–2.9	3.6–6.0	70–71.8	4.6–5.5	93–95	3–4 rubles
Five-stage fluidized-bed	21	6.7	<2.4	2200–2700	3–4	3–3.3	62–64,5	—	95–97	1.35–1.5 dollars

were fired with blast-furnace and generator gas. At present such kilns are in use in the Federal Republic of Germany; yet recently the Lurgi Company published an announcement where it guarantees construction of rotary kilns of 600-1100 ton/day capacity which may be pushed up to 1600 ton/day, whereby the fuel consumption is reduced to 3.6%. The length has been increased to 60 m and the diameter to 4.0 m. In the Chinese People's Republic there are 30 shaft furnaces in operation which have a volume of 55 m^3 and a capacity of more than 400 tons per day while the fuel consumption is 3-4%.

In recent years experiments were conducted on the magnetizing roasting of fine iron ores in fluidized beds. So far, the fluidized-bed reactor still needs proving-out on an industrial scale.

Performance data for the above furnaces are given in Table 1.

Shaft furnaces are the most perfect thermal processing units for roasting of ores: the products of combustion leave the furnace at 100° and the roasted ore at 250-350°. These furnaces are characterized by a high specific productivity and a low capital requirement for construction. In the case of the Anshansk furnaces which roast quartzites, 12-75 mm lump size and 15% fines, the specific productivity reaches 7.3 ton/m^3/day; when sorted ore is used (25-75 mm) the latter may be raised to 10 ton/m^3/day. The disadvantages specifically common to the shaft furnace are the uneven distribution of gases and uneven charge descent; these present difficulties in designing furnaces of higher than 500 ton-per-day capacity. Even for this capacity the furnaces must be rectangular where the width is no more than 1.5-2 m; this fact complicates their construction.

The rotary kiln is the only industrially proven unit which may have a capacity of 1000 tons per day while producing a high quality magnetizing roast. However this type of furnace is bulky and equipping it requires large expenditures. Roasting costs when using this furnace are high because of the relatively low specific productivity (2.5 ton/m^3/day), high fuel consumption (up to 6%) and wear of mechanical equipment. From the point of view of thermal efficiency the furnace is not good. Roasted ore is discharged at 300° and gases exit at 500°. Improvements to the furnace, in order to achieve a more complete heat recovery from the roasted ore, complicate the design and operation. In order to equip a rotary kiln much metal is needed.

Fluidized bed reactors for reducing roasting iron ores are not yet in production in ferrous metallurgy. Yet judging by experimental data compiled in other branches of the industry it can be expected that such reactors will be capable of roasting large quantities of iron ores. Investigations have shown that the reaction rates are very high when fine ores are subjected to magnetizing roasting in the fluidized bed. The combined heating time and reduction time for the iron-ore particles does not exceed 15-20 minutes at relatively low concentrations of CO and H_2 in the gas and at relatively low temperatures. And yet these favorable properties of the fluidized bed also are at the root of its limitations:

1) as a result of the strong particle mixing in the bed utilization of the heat in the gases does not exceed 15%; 2) when the ore is charged and discharged continuously the particle retention time is not constant and as a result the ore roasted in a single stage reactor is not of uniform quality.

In order to circumvent these disadvantages it is necessary to design multistage furnaces. This enables reducing the specific fuel consumption from 10-12% to 3-4%, and improving the quality of the calcine; however, the design, erection, and operation of the unit is complicated.

A four-stage reactor has been designed by the Gas Utilization Institute of the Academy of Sciences, Ukrainian SSR. This reactor is now under construction at the Southern Mining and Concentrating Combine (S.M.C.C.) at Krivoi Rog (Fig. 3).

A roasting furnace operates most effectively when treating ore of definite particle size. Fine grained ore (less than 2-3 mm) should be roasted in fluid-bed furnaces. In order to minimize carry-over of dust particles from the bed and to regulate the removal of particles in a semireduced state, the charge should consist of fractions whose maximum and minimum particle size bears a ratio of 10-20. Ore of particle size 3-25 mm should be roasted in rotary kilns. Coarse size ore, with a maximum to minimum lump-size ratio of 2-4, as for example the 25-75 mm fraction, is best roasted in shaft furnaces. Specifically, it is inadmissible to design only rotary kilns for the treatment of Krivoi Rog quartzites and Lisakovsk limonites as the Mekhanobr and Mekhanobrchermet are doing. The fine grained Lisakovsk ores, where the majority of particles are less than 2 mm, should be roasted in fluid bed furnaces. For the concentration by magnetizing roasting followed by magnetic separation in the case of the mechanically

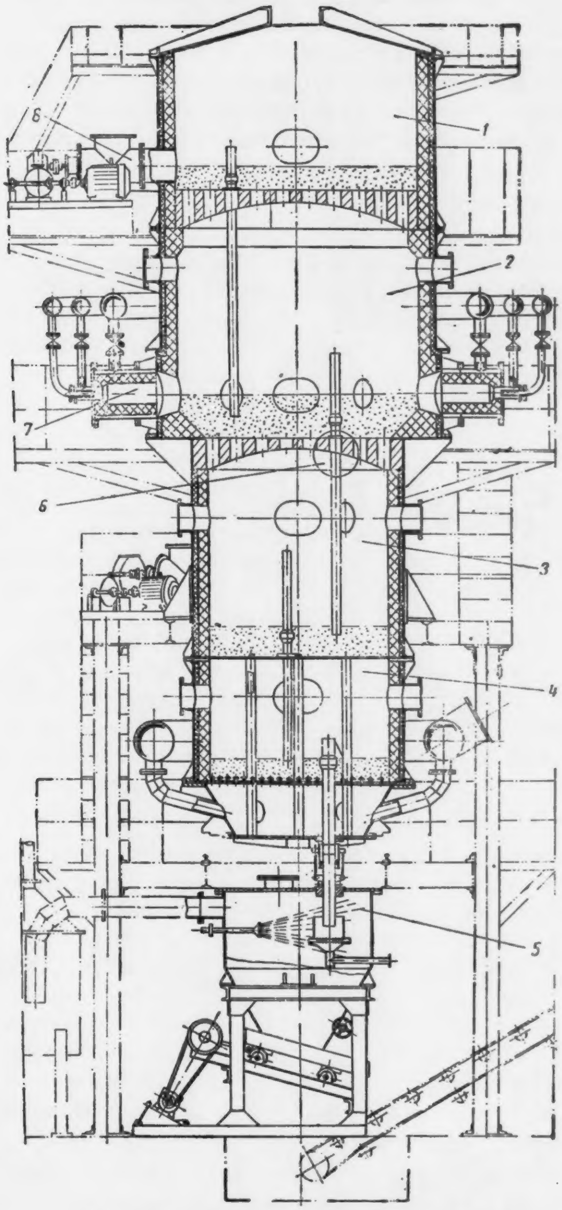

Fig. 3. Four-stage fluidized-bed reactor; 1) drying zone; 2) preheating zone; 3) reduction zone; 4) cooling zone; 5) unloading bin; 6) grate with a transfer tube; 7) burner; 8) feeder.

strong Krivoi Rog hematite quartzites, the most logical route is crushing to 75 mm followed by screening into two fractions, minus 3 mm, 3-25 mm and 25-75 mm. The first should be roasted in a fluid bed, the second in rotary kilns and the third in shaft furnaces. In such a beneficiation scheme the matter of furnaces becomes rather complicated. Norwithstanding this the economics of a combine will be better and the capital investment lower. The magnetizing roasting flowsheet involving three types of furnaces is best suited for large mining and concentration combined such as, for example, the Central Mining and Concentration Combine (C.M.C.C.) which will beneficiate 9 million tons per year of oxidized quartizites. At present three types of production-scale experimental furnaces (shaft, rotary and a fluid-bed reactor) are being constructed at the S.M.C.C. Only after the evaluation of these furnaces should the final decision be taken as to their industrial application.

One of the main factors which retard the introduction of concentration of iron ores by magnetizing-roasting–magnetic separation is the high cost of the roasting step. The major part of the roasting cost is the fuel cost. Accordingly the cost of fuel at the magnetizing roasting concentration plants at Braunschweig and at the Anshansk Metallurgical Combine are 50 and 30%, respectively, of all the concentrating costs (based on one ton of concentrate). The same applies to the process of roasting in a fluidized bed. Thus it is imperative that cheap and less difficultly available fuels are used in the magnetizing roasting plants; moreover a complete utilization of the heat-content of the combustion products and the roasted ore must be achieved.

TABLE 2. Specific Fuel Consumption for Roasting Hematite Quartzites

Type of furnace	Gas consumption, % of the ore weight: blast-furnace	Gas consumption, % of the ore weight: natural or coke-oven
Shaft	3.0–3.5	3.5–4.0*
Rotary	3.6–6.0	4.5–6.5*
Multistage fluidized-bed . .	3.0–4.0*	5.5–7.5*

*Calculated values.

Roasting of iron ore proceeds very well in the gas phase while there is a relatively low CO and H_2 concentration. Accordingly a gas which has a low heating value (e.g. blast-furnace gas) is most suitable for use in reducing roasting. At a high CO and H_2 concentration (coke-oven gas) and a temperature of more than 573°, "overroasting" of the ore occurs and as a result the recovery of iron into the concentrate is decreased. The above temperature invariably exists in some part of the roasting furnace. At temperatures below 700° iron oxide cannot be reduced to a magnetic state by solid carbon; thus gas only should be used in roasting furnaces. Use of natural gas in these furnaces does not give any benefits, it must therefore be converted with air prior to being used.

The best fuel is blast-furnace gas. Its cost is never higher than 1.0-1.2 kopeks, while natural gas is sold to industrial concerns at 1.25-1.5 kopeks, coke-oven gas at 1.5-2.0 kopeks, and producer gas at 4-5 kopeks for every 1000 kcal. The blast-furnace gas is the most economical fuel also because of the fact that roasting-furnace operation is optimum when it is used (Table 2). Because of its low heating value the blast-furnace gas is introduced into the furnace at a rate of 250-500 m^3/ton of roasted ore while the consumption of natural gas does not exceed 30-65 m^3/ton. As a result the roasted ore is cooled to a lower temperature than in the case of roasting with natural or coke-oven gas. According to data in the literature roasted ore is discharged from shaft furnaces and rotary kilns, which are fired with blast-furnace and producer gas, at a temperature of 250-350°. According to our calculations and foreign data the discharge temperature of roasted ores from four or five-stage fluidized-bed furnaces will not exceed 400-425°. When the ore is roasted with natural gas or coke-oven gas in shaft furnaces, rotary kilns and/or two-stage fluidized-bed furnaces, the roasted ore will be discharged at a temperature of 500-700°.

An analysis of heat balances and technical aspects of various fluidized-bed plants for roasting fine grained hematitic quartzites shows that, although the design and the application of a single stage fluidized bed reactor is simple, roasting in a single stage fluid bed is not industrially attractive. This is because the specific fuel consumption is more than 10% of the weight of the ore. Use of the heat-content of the exhaust gases for predrying the ore reduces the fuel consumption to 6.5-9%. Only in four or five stage reactors, where the ore is dried, heated, reduced and cooled by the reducing gas in stages located one above the other, is the temperature of the roasted ore and the exhaust gases lowered to 425 and 175°respectively; then fuel consumption is 3-4%. Multistage fluidized-bed furnaces can be designed only when based on blast-furnace gas. In the case where natural gas is used and its incomplete-combustion products with air serve as the heat carrier and reducing agent, furnaces with not more than two or three stages must be used; then the fuel consumption can be lowered to 5.0-7.5%. The

Chinese concentration experiments confirm the effectiveness of using blast-furnace gas instead of coke-oven gas. When the Anshansk shaft furnaces were changed over to blast-furnace gas, 40% of the fuel was saved and the iron content in the tailings after magnetic separation dropped from 15 to 12%. A further replacement of coke oven gas, which was fed to the reduction zone, with a mixture of coke-oven and blast-furnace gases having a heating value of 1100 kcal/m^3 has given an additional reduction in fuel consumption and an increase in furnace productivity.

Accordingly, blast-furnace gas appears to be the best fuel and reducing agent for the roasting furnaces and it should be used, first of all, for the magnetizing roasting of iron ores. Only when there is no blast-furnace gas available should natural gas be used; then it ought to be used in rotary kilns. Under conditions which exist in the Krivoi Rog basin, where there is an extensive metallurgical industry utilizing the converter process, all possibilities exist to utilize the excess blast-furnace gas for the roasting of hematite quartzites at the S.M.C.C. and the New Krivoi Rog Mining and Concentrating Combine. Also the question of using natural gas for roasting 9 million tons per year of quartzites at the Central Mining and Concentrating Combine which is located 23 km from a metallurgical plant should be reviewed.

EXPERIENCE IN USING EQUIPMENT AT SINTERING PLANTS

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at the "Zaporozhstal' " Plant
Translated from Metallurg No. 10, pp. 7-11, October, 1960

In May-June,1960,an All-Union interworks course was held on the intensification of the sintering process and increasing the quality of fluxed sinter. The course was attended by 32 representatitives from most sintering plants in this country. The author, who also took part, describes the latest experience in the operation, modernization and automation of equipment at sintering plants which the course visited. The article on the work of the school will be published in one of the issues of the "Metallurg" journal.

Sintering Machines. The most noticeable results in the use of sintering machines with 50 m^2 sintering area have been achieved at the "Zaporozhstal' " Sintering Plant. The use of palettes of special design of width 2,500 mm has increased the sintering area from 50 to 62.5 m^2 while maintaining the area of the vacuum chamber*. As well as redesigning the extractors, the feed of lime to the charge and other improvements have increased the output to 110 ton/hr from one sintering belt.

At the sintering plants of the Magnitogorsk Combine the end seals of the last vacuum chambers have been made wedge-shaped: moving sealing plates have been applied (in the form of a reverse wedge) to the fixed plates which are chamfered in the direction of movement of the palettes. Their top surface is pressed to the bottom surface of the palettes by means of levers with springs. In contrast to the standard sealing with a fixed plate,this design practically eliminates the harmful leakages through the end of the last vacuum chamber. The wedge sealing is used at the Yuzhuralmashzavod in 75 m^2 machines for the sintering plant of the Cherepovetsk Metallurgical Plant.

At the Magnitogorsk Metallurgical Combine sintering plants,the rubber hoses of the hydraulic seals are protected by asbestos cloth, which has made it possible to increase their durability. The antifriction bearings of the palette roller are separated by a partition. This protects each bearing from damage by the rollers of the second bearing in the event of their failure. This design together with the fastening of the castellated nut by a cotter pin prevents the roller jumping from the shaft.

*Stal', No. 6, 1960.

It should be mentioned that the roller design developed in 1957 at the "Zaporozhstal'" Plant for a wider palette, having a splined castellated nut and a stopper transverse strip on two screws (the type of palette of the K-3-50 sintering machine) is more reliable and convenient for controlling the bearings.

At the Krivoi Rog Plant,in the rollers of two sintering machines of the UZTM there were roller bearings 27313 made by the No. 9 bearing plant. They are more serviceable than the previously used 7513 bearings.

At the sintering plant of the Cherepovetsk Plant instead of the usual bearing plate of the igniting hearth cooled by coolers attached at the bottom, a hollow water-cooled plate was used.

At the 75 m^2 sintering machines of the Alchev Plant they use scraper removal of the spillage from the idle branches of the sintering machines. The overlapping under the idle branch is made in the form of a metallic chute in which a small scraper moves along guides, driven by a winch with a pulling force of 800 kg. The scraper collects all the spillage into the discharge part of the machine. This design should be improved by providing reverse movement of the scraper along the upper rails over the spillage (in order to eliminate the undesirable falling of fines into the head part) and reliable protection of the scraper cable from overheating (when using a chain as the end section). The new method of removing the spillage will then find wide application since it completely eliminates physical labor used to clean the wast from the grating and considerably reduces the liberation of dust.

At the sintering plant of the "Azovstal'" Plant the clearance between the knife for removing the cake in the unloading part of the machines and the palettes can be controlled by two connecting rods which compensates the wear of the knife.

Extractors. In most of the sintering plants the 50 m^2 area sintering machines are fitted with D-3500-13 and D-3500-12 extractors with motors of nominal power 1300 kw. The motors are loaded at approximately 900 kw, which makes it possible to redesign the extractors with an increase in their output.

At the "Zaporozhstal'" Sintering Plant all extractors have been fitted with universal diffusers and the rotors have been increased by 25% along the width and up to 2080 mm along the diameter.

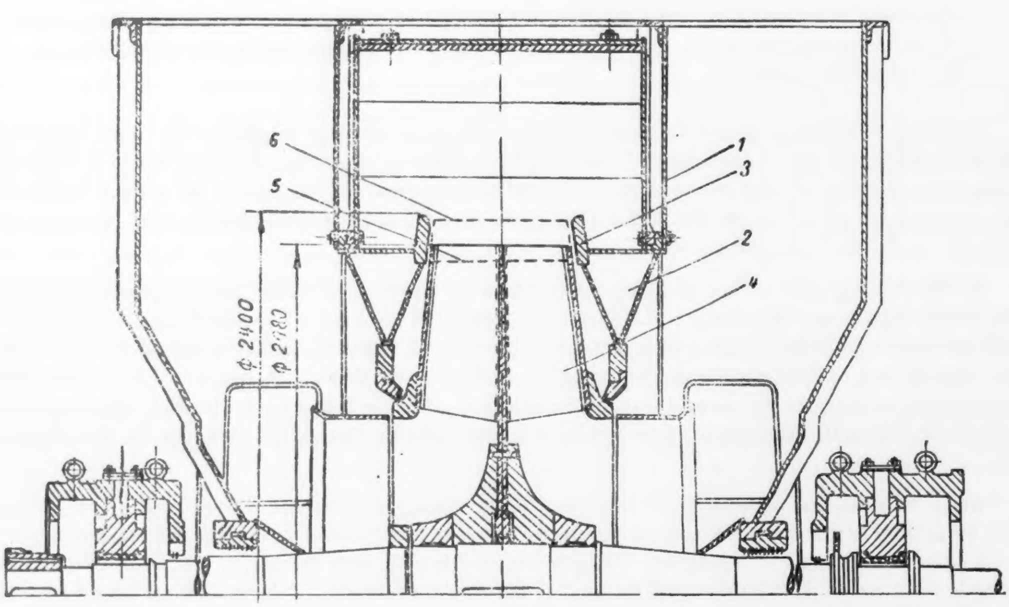

Fig. 1. Diagram of universal diffuser: 1) body of extractor; 2) diffuser; 3) external ring of diffuser; 4) rotor of diameter 2080 mm; 5) boundary of a typical rotor of diameter 1940 mm; 6) boundary of possible increase in diameter of the rotor to 2300 mm.

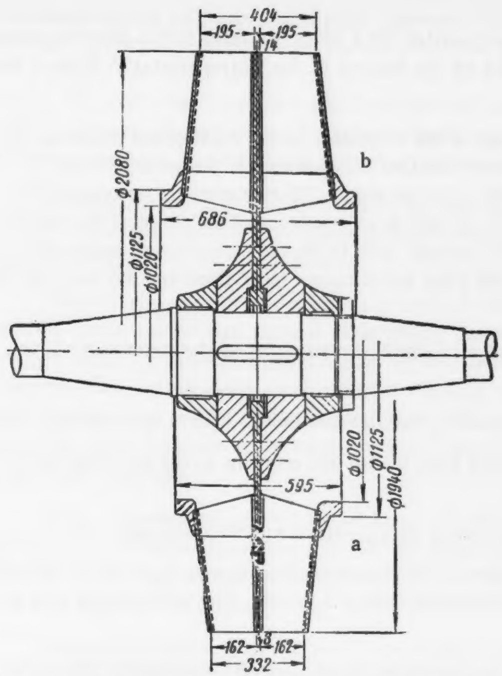

Fig. 2. Redesigning of extractor rotor: a) before redesigning; b) after redesigning.

Fig. 3. Assembly unit—universal diffuser combined with the rotor of the extractor.

The universal diffuser (Fig. 1) with tapered external rings makes it possible to install in the body of the extractor a rotor of any dimension along the external diameter (from the minimum to the maximum permissible) and to select the optimum parameters of the extractor.

The diagram of the redesigned rotor is shown in Fig. 2. The diffusers were replaced during planned overhauls of the sintering machines (28-36 hr) together with the rotors, collecting them in an assembly unit (Fig. 3).

The redesigning increased the output of the extractors to 4800 m^3/min with a pressure drop before the extractor of 1100 mm water column. The loading of the motor reaches 1300 kw. The redesigning of the extractors increased the sinter production by 9% under the conditions of the "Zaporozhstal' " Plant.

The redesigning of each extractor with the manufacture of a new rotor costs 25 thousand rubles.

At the "Zaporozhstal' " Plant, tests were carried out over a period of 2 days on an extractor with a 2200 mm diameter rotor which showed an output of 5150 m^3/min for the three closed (due to overloading of the motor) vacuum chambers, a vacuum of 1160 mm water column, and gas temperature of 150°. The loading of the motor was then 1430 kw. The plant intends to convert the extractor to these rotors with the replacement of motors by more powerful equipment.

The output of the extractors can also be increased by other methods. At the Makeev Plant they are planning to install new extractors 6500-11-1 instead of the existing D-3500 type extractors. However, this requires strengthening of the structure under the frame and the replacement of the extractor section crane, a complete change in the foundations, and much other complex work. These extractors were installed at the Krivoi Rog Sintering Plant, they increased the productivity of the sintering machines by about 10%.

At the sintering plant of the Dzerzhinskii Plant in addition to the six operating extractors D-3500-13 and D-3500-12, one 3500-14-1 extractor has been installed with a common gas pipe. The cost of this work is estimated at 1.3 million rubles, the expected effect is a 5% increase in the output of each sintering machine.

The 1960 Interworks Course for sintering workers recommended for a 50 m^2 sintering belt a sintering extractor of 500 m^3/min capacity. The redesigning of the extractor by the method of the "Zaporozhstal' " Plant is the quickest and most convenient solution of this problem.

A manual oil pump was used to feed oil to the bearings of the extractors during starting and stopping. At the "Zaporozhstal' " Sintering Plant,for this purpose they have installed the electric oil pumps ShDP-50 of 50 liter/min delivery at a pressure of 13 atm and 1500 rpm with a 2.8 kw motor. These pumps are automatically switched on when the extractor is started, and it is stopped if there is an emergency breakdown of the mechanical pump, driven by the shaft of the rotor,and also when the pressure falls in the oil pipe network below the established value. The electric pump also stops automatically after the extractor has started and the load has been taken up by the mechanical pump.

Coke Crushers. At the "Zaporozhstal' " Sintering Plant all 4-shaft crushers with single-motor drive have been redesigned. The following steps were taken.

a) in 1954,the speed of the shafts was increased by replacing the 730 rpm motors by 970 rpm motors;

b) the external diameter of the bands has been increased from 900 to 950 mm, the bands are made of 70 KhL steel;

c) at the start of 1960,at the three crushers the 46 kw motors were replaced by 75 kw motors.

These measures have increased the output of the crusher to 25-30 ton/hr (the planned figure is 15 ton/hr) without changing the quality of the crushing. The life of the bottom rolls is 4 months, that of the upper rolls is 8-10 months.

At the Makeev Plant they use forged bands of 45G2 steel made by DZMO, which increases the life of the band by eliminating the flaws which are inherent in castings. At the Magnitogorsk Metallurgical Combine Sintering Plant they use steel bands of the following chemical composition, %:

C	Si	Mn	Ti	P	S
0.57—0.63	1.00—1.50	1.50—2.0	0.11—0.2	0.03	0.03

It is essential to further redesign the coke crushers using rigid-cast beds and antifriction bearings for the rolls, which should provide complete interchangability and make the replacement operation similar to roll changing in the stands of a rolling mill. The crushers whould also have low-inertia reliable shock absorbers (the oil-nitrogen type) and it should be possible to grind and machine the bands during crushing.

Screens. The most productive and reliable are the VGD-2 double-deck screens (1500 x 3000 mm) of the Debal'tsevskii Plant and the 1500 x 3000 TsKB screens. Experience at the "Zaporozhstal' " Plant indicates that when the VGD-2 screens are used the suspension should be changed: instead of a laminated-leaf spring system and support,the screen is fastened on springs directly behing the box.

The vibration screens of the TsKB of Glavmashmet (previously the Dnepropetrovsk PKTI) are more powerful. To install a second grate on the distance tubes of the box it is essential to build a second deck. The grate of these screens is fastened weakly and is heavy; in all instances it is therefore replaced by a wire grate (to screen the limestone or separate the bed from the charge at the "Zaporozhstal' " Plant) or a bar sectional grate (screening the cooled sinter at the Cherepovetsk Plant).

Using a specimen of the TsKB screen at the YuGOK* sintering plant a screen has been developed and built to screen the hot sinter. It has been installed under the stationary screen with a 40 mm slit protecting the vibration screen from the impact load of large pieces of sinter. The dimensions of the vibration screen are 2000 x 3000 mm, the grate is made of bars of 10 mm diameter with a slit between them of 6-8 mm, the drive is from a 21.5 kw, 980 rpm motor through a Texrope transmission. In the middle of the box of the screen there is a longitudinal wall for rigidity. The four corners of the screen rest on assemblies consisting of two cylindrical springs. The shaft of the vibrator with a 21 mm eccentricity runs at 810 rpm and has a water-cooled housing.

On one of the sintering belts of the Dzerzhinskii Plant there is an experimental apparatus for screening hot sinter (the author of the project is G. G. Oreshkin). After a single-roll toothed-roll crusher,the sinter passes through

* Suggested by Grigor'ev, Migutskii,and Savitskii.

a stationary screen and arrives at a plate conveyer which feeds the sinter into a double sleeve funnel and from here into one of two self-balancing screens (the second reserve). The upper product (greater than 8 mm) is loaded into a hopper and the screenings less than 8 mm are collected by a plate conveyer through a funnel into the return bunker. The apparatus has been working completely reliably since April 15, 1960 and, having a 100% reserve with regard to screens, has not caused holdups in the operation of the sintering machine. After screening, the content of 0-5 mm fraction in the sinter is 3-4% (without screening it is 10-11%).

However, mention should be made of the complexity of this machinery and its high cost—1.3 million rubles. In view of the existing tendency to screen cooled sinter as close as possible to the blast furnaces, in our opinion this machinery is not very promising.

Plate Conveyers. Presently, due to a lack of rubber conveyer belts of sufficient heat resistance at many sintering plants and in blast furnace departments the tendency is to use plate conveyers to transport hot sinter and returned material. This has been initiated by the Cherepovetsk Plant. The conveyers are based on the rolling of rollers of an endless chain along stationary guides. Including the rollers among the moving elements of the chain increases the weight of the moving parts, increases the power of the drive, makes it necessary to have guides, makes the conveyer more sensitive to bending, excludes the possibility of using automatic entralized lubrication of the roller bearings.

These conveyers should not be confused with the plate conveyers used in the Magnitogorsk Metallurgical Combine blast furnace department to load the skips (instead of the scale cars). The rolls of these conveyers are stationary; they support the moving chains with the plates fastened to them. With good quality manufacture and sufficient rigidity of the plates, these conveyers operate reliably and with long periods between repairs.

Vibrating Feeders. A new type of equipment at sintering plants, which has been used successfully at the Alchev Plant, is the 1200 x 6000 mm vibrating charge feeder. It is a horizontally suspended tray with flanged edges open at the top and at the bottom (at an angle of 20° to the horizontal); there are two electrical vibrating drives of up to 4 kw power. The feeder delivers charge to the mixing drum at the sintering machine. The vibrating feeders were designed by the "Mekanobr" Institute and built by the Parkhomenko Plant, the vibrating drives were built by the Karl Marx Plant (Pervomaisk-Lugansk region).

Filter. In connection with the widespread use of the method of hydraulic removal of multicyclone dust, the extensive use of hydraulic washing of walls and floors of the buildings, and the washing of the ventilation discharge, a sharp need has recently been felt for a reliable and high-output thickening mechanism, operating without filter cloth.

At the Magnitogorsk Metallurgical Combine Ore Enrichment Plant, vacuum cell filters have been installed, these being manufactured at the K. Liebknecht Plant in Magdeburg (East Germany). The filter is a round horizontal plate of 3340 mm diameter, rotating about a vertical axis at a speed of 0.5 rpm and driven by a 5 kw, 970 rpm motor through a worm reducer and an open gear transmission. The top of the plate is a ring-shaped filtering surface of 6 m^2 area, consisting of sheets of phosphor bronze having fine slits. The pulp is fed directly from above onto the filtering surface, the residue is removed by a stationary flat scraper (knife) and is thrown onto the belt conveyer. The filtrate passes through the plate into a collector and is removed through the distribution head under the plate. The filter weighs 13 tons and measures 4 x 5 x 3 m.

The filter is fitted with a 1620 m^3/hr vacuum pump giving a 4000 mm water column vacuum. The capacity of the filter is up to 40 tons/hr. The pulp with a solid to liquid ratio of 1:20 is thickened in a hydrocyclone to a ratio of 1:4 before passing through the filter, the moisture of the products obtained after the filter is 6-10%. These filters will undoubtedly find extensive use in enrichment and sintering plants.

Car-Sample Classifier. At the present time, samples of sinter for sieve composition are taken and sieved manually, which involves physical labor and does not give a true idea of the sieve composition of the sinter. At the Enakievsk Plant they use a special car on which is mounted a bunker for the sinter and under it a GZh-3 1250 x 2500 mm screen with a 5 mm mesh, a container with a seal for the fines under the screen, and a chute for the useful sinter. The car is first weighed and then placed under the sintering belt, loaded with a fixed amount of sinter (20 tons), and together with the ventilator of the hoppers with the sinter it is weighed and sent to the hoppers the screen is connected to the electrical circuit and the whole sample is screened. The useful sinter is unloaded along the chute into the bunker of the blast furnace department, the fines less than 5 mm remain in the container.

Problems of Automation. The following forms of centralized control and automation are used at the sintering plants.

1. Centralized starting of the conveyer tracks and the production flow using weak-current apparatus of the telephone type (sintering plants of the Chelyabinsk, Cherepovetsk and Alchevsk Plants).

2. Automatic switching of the charge feeders (with regard to yield of materials), starting and stopping of the set of feeders (sintering plants of the Chelyabinsk and Krivoi Rog Plants).

3. The automatic uniform distribution of charge at different sintering machines. At the "Zaporozhstal'" Plant the auto-feeders operate according to the shuttle method, the filling of the end bunkers being controlled by means of electrodes. At the Magnitogorsk Metallurgical Combine the charge is distributed continuously by operating gate valve distributors of the pendulum type. At the "Azovstal'" Plant the charge is fed into the bunkers of the sintering machines by means of a periodically overlapping (every 5 sec) gate valve with an electric drive. At the Makeev Plant they use a gate valve with a hydraulic drive, overlapping when the bunkers are filled to a given level.

4. Automation of the loading of the charge, cutting off the gas and water when the sintering machines stop and automatic control of the speed of the sintering machine with regard to the degree of completeness of the

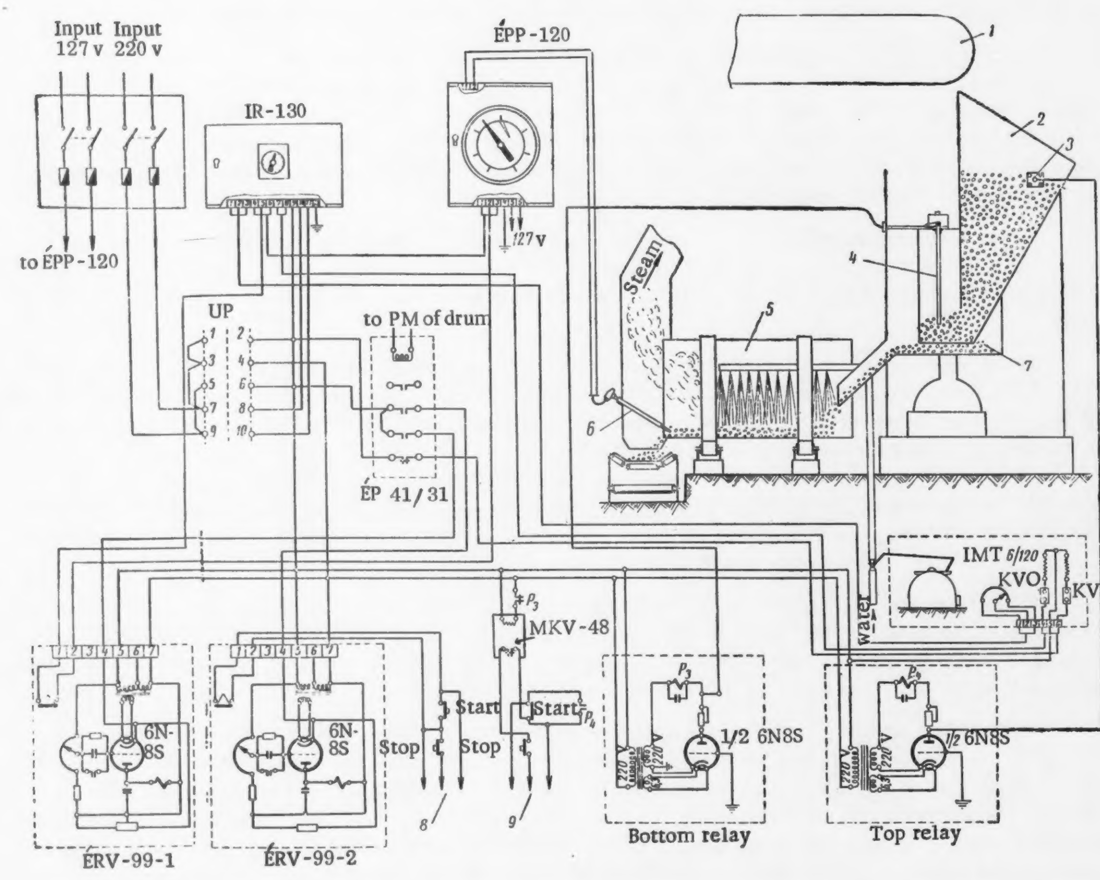

Fig. 4. Main Circuit for the automatics of delivery and cooling of return material: 1) sintering belt; 2) return bunker; 3) upper electrode; 4) bottom electrode; 5) drum; 6) thermocouple; 7) return feeder; 8) return feeder control; 9) drum control.

sintering process with the impulse obtained from the temperature of the gases before the multicyclone ("Zaporozhstal' ").

5. Automation of the igniting hearths.

6. Automatic cutoff of the vacuum chambers when the sintering machines stop (sintering plant of the Zakavkaz Plant).

At the Dzerzhinskii Sintering Plant they are completing the introduction of an automation system for delivering and cooling returned material; this has been designed by V. F. Pocht, an engineer in the Automatics Laboratory (Fig. 4). In the return bunker there are two electrodes: for the upper level (0.5 m below the last row of firegrates of the screen) and for the bottom level (0.5 m above the surface of the return feeder plate). The stainless steel electrodes are given a hard facing to reduce wear. The supply of water to the drum-cooler is regulated by a stopcock controlled by an IMT-6/120 type executive mechanism. The temperature of the cooled returned material is measured by a low-inertia thermocouple, the hot junction of which (in a thin cover built up with sormite) is placed in the stream of the delivered returned material.

The circuit is made up of three 6N8S tubes, two ÉRV-99 time relays with a time delay of 40-60 sec (transition from semiautomatic to automatic system of cooling) and 15-20 sec (the pause from the moment of switching on water to starting the plate feeder), with an ÉPP-120 electronic potentiometer, controlling the temperature of the returned material, and a proportional speed floating controller type IR-130, controlling the temperature of the returned material.

The drum of the returned material and the feeder are automatically switched on when the bunker is filled up to the top electrode and are switched off when the bottom electrode is free of returned material. The amount of cooling water is determined by the temperature of the returned material (by its deviation from a given value).

THE DEOXIDIZATION AND ALLOYING OF CHROMIUM STEEL WITH SILICOCHROMIUM IN THE LADLE

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During the production of chromium steel it is usual to introduce ferrochromium into the melt after the preliminary deoxidization. In connection with the high melting temperature of ferrochromium (1470-1540°) and the difficulty in the assimilation of chromium carbides by the metal it is necessary to keep the metal in the furnace for 25-30 minutes after the addition of ferrochromium and this reduces the output of the furnace and increases the cost of steel production. In addition, if ferrochromium is added into a melt which has not been deoxidized beforehand chromium oxide, apparently, dissolves in the metal melt resulting in poor metal properties. However, in spite of the advantages of a preliminary deoxidization of steel before the addition of ferrochromium, steel melters at several works prefer deoxidizing and alloying the steel in the ladle.

The addition of chromium to steel by the introduction of silicochromium into the ladle was started at the Kuznetsk Metallurgical Combine as early as 1942.* Five experimental heats of steels 30KhGSA, 35KhGSA and 40SKh were carried out; between 50 and 100% of the required chromium was introduced into the ladle. However, because of the insufficient firing rate of the open-hearth furnaces at that time and because it was impossible to increase the firing rate in furnaces with silica roofs and mainly because of the shortage of commercial silicochromium, it was not possible to adopt this method of deoxidization.

The introduction of magnesite-chromite refractories for the open-hearth furnace roof made it possible to heat the metal to the temperature required for the deoxidization and alloying of the steel in the ladle and at the same time to obtain a high quality steel.

60 experimental heats of chromium, chromium-nickel and chromium-silicon-manganese steels including six heats of 20Kh steel, 30 heats of 40Kh steel, two heats of 45Kh steel, two heats of 17KhN2 steel, two heats of 40KhN steel and 18 heats of 15KhSND steel were carried out in 190-ton furnaces at the Kuznetsk Metallurgical Combine during the period between May and September 1959. For comparison, 26 heats of the same steels were deoxidized by the usual method. The experimental heats differed from the ordinary ones only in the method of deoxidizing and alloying the metal in the ladle.

For the deoxidization and alloying of the metal in the ladle, Sikhr 18 silicochromium which contained 18-20% silicon, 48-50% chromium, 3-3.5% carbon, and 0.05-0.07% phosphorus, was used. Deviations in the content of silicon and chromium in individual batches of silicochromium did not exceed 3% of their content in an average sample. No metallic inclusions were found either inside or on the surface of the silicochromium particles.

* The methods for the deoxidization and alloying of chromium and chromium-silicon steels with silicochromium in the furnace and in the ladle were developed in the U.S.S.R. by engineers A. I. Khomutov, V. E. Leikin and T. I. Sakharuk. The addition of grade Sikhr 30 and Sikhr 50 silicochromium into the ladle was tested at the Magnitogorsk Combine and at the "Krasnyi Oktyabr'," Serov, Zlatoust, Il'ich, Kulebaka, and other Works.

TABLE 1. Quantity of Ferro-Alloys Added in Experimental Heats

Steel	Addition, kg/t				Total silicon added, %
	into the furnace			silicochromium into the ladle	
	ferromanganese	18% ferrosilicon	ferrochromium		
20Kh	12.3	7.2—7.3	4.1—4.6	13.3	0.38—0.40
40Kh	10.2—14.3	7.7	5.1—6.7	12.7—13.3	0.38—0.43
45Kh	10.7	7.7	6.7	13.3	0 40—0.41
17KhN2	8.2	7.1—7.2	2.1	13.2	0.40—0.42
40KhN	11.3	9.2	—	11.3	0.40—0.43
15KhSND	Silicomanganese 9.7—10.3	45% 4.6—6.2	—	14.3—17.5	0.63—0.77

TABLE 2. Loss of Manganese, Silicon and Chromium from Heats Deoxidized with Silicochromium in the Ladle and with Ferrochromium in the Furnace

Steel	Heats	Number of heats	Loss, %		
			manganese	silicon	chromium
20Kh	Expt.	6	24.0	28.1	5.2
	Ordinary	4	30.5	50.0	15.3
40Kh	Expt.	30	22.2	28.2	9.6
	Ordinary	10	17.7	36.7	13.1
45Kh	Expt.	2	17.1	19.5	10.5
	Ordinary	4	26.8	38.4	16.6
17KhN2	Expt.	2	23.3	31.0	10.3
	Ordinary	2	16.0	46.7	17.5
40KhN	Expt.	2	17.6	43.0	7.2
	Ordinary	3	21.5	43.6	10.3
15KhSND	Expt.	18	20.7	20.0	12.9
	Ordinary	3	28.0	42.5	22.6

TABLE 3. The Mechanical Properties of the Steels from Experimental and Ordinary Heats

Steel	Heats	Number of heats	Mechanical properties				
			σ_s, kg/mm²	σ_b, kg/mm²	δ, %	ψ, %	a_k, kg/mm²
20Kh	According to GOST		60	80	10	40	6
	Experiment.	6	88	96	16	52	12.4
	Ordinary	4	79	88	16	51	12.3
40Kh	According to GOST		80	100	9	45	6
	Experiment.	30	98	108	13.8	51.7	10
	Ordinary	10	95	105	13.7	55	10
45Kh	According to GOST		85	105	8	40	5
	Experiment.	2	94	106	15	52	11.6
	Ordinary	4	106	116	13	50.6	7.7
17KhN2	According to GOST		60	80	12	40	8
	Experiment.	2	110	116	13	55	11.7
	Ordinary	2	112	123	12	50	10.5
40KhN	According to GOST		80	100	10	45	7
	Experiment.	2	102	109	14	56	11.3
	Ordinary	3	99.5	107	13.5	53	10.1
15KhSND	According to GOST		35	52	18	—	3
	Experiment.	18	40.3	56.6	19.4	—	10.5
	Ordinary	3	41.1	54.5	20.0	—	9.7

Before being added into the ladle, the silicochromium was crushed to a maximum particle size of 70 mm. Then, during the tapping, it was added to the stream of metal in the ladle from suspended bins fitted with a special stopper.

The quantity of ferro-alloys added for the deoxidization of metal in the furnace and in the ladle fluctuated within certain ranges for some of the steels in the experimental heats (Table 1)

The absolute and percentage losses of manganese, silicon and chromium were calculated for the experimental and ordinary heats (Table 2). The loss of silicon and chromium in the experimental heats was significantly lower than in the ordinary ones, and the loss of manganese was lower for steels 20Kh, 45Kh, 40KhN, 15KhSND but somewhat higher for steels 40Kh and 17KhN2.

Thus, the replacement of ferrochromium by silicochromium and the addition of silicochromium into the ladle results in a significant reduction in the losses of silicon, chromium and manganese.

The chemical composition of the steel at the time of tapping usually varies. This nonuniformity is subsequently eliminated to a great extent by mixing of metal in the ladle and this depends on the circulation caused by the metal steam, on thermal convective currents and on the turbulence in the ladle. Tests on the variations in the chemical composition of steel in the course of tapping were made for all experimental heats. Samples were taken at the beginning, in the middle and at the end of each tapping. Chemical analysis shows that in the course of the tapping, the variation in the composition of the steel, when

the steel is deoxidized with silicochromium in the ladle, follows the usual rules, that is, there is a slight oxidation of silicon and the reduction of phosphorus at the end of the tapping. The chemical composition of all steels with regard to manganese, silicon and chromium, in the first, middle and last ingots does not vary basically by more than 0.02-0.04% which indicates a uniform distribution of all elements over the whole bulk of the metal in the ladle.

If there is an irregularity in the method of adding silicochromium, the chromium content in the last ingots from a heat may be higher and, therefore, the last ingots have to be analyzed for their chemical composition in order to prevent the dispatch of substandard steel to customers.

Table 3 shows the average mechanical properties of steels from experimental and ordinary heats. The properties of the metal deoxidized with silicochromium in the ladle are much better than those specified by GOST and are practically the same as those of metal deoxidized by the ordinary method.

The internal structure of steel deoxidized by silicochromium in the ladle is quite satisfactory. There were no rejects on account of segregation or pipe formation in ingots; there were very few rejects in the finished rolled product only on account of impurities and inclusions of refractories in the outer zone. Therefore a proper preparation of the hot tops for the pouring of chromium steel is essential.

Inspection of the macrostructure indicated that all experimental steel was without defects; all ingots at all cross sections were classified as group "A".

The high mechanical properties of metal deoxidized with silicochromium in the ladle, and the absence of macrostructure defects indicate that the quality of the chromium steel is not impaired by this method of deoxidization. The gas which is in the metal separates from it over a long period of time but a considerable quantity of the gas still remains. The gas in the killed steel can be present in the form of submicroscopic bubbles. The accumulation of gases in the central part of the ingot at the end of the solidification period assists in the formation of the pipe. This is the cause of the formation of microscopic shrink holes in the form of hair cracks on grain boundaries.

The presence of gases manifests itself in the final product mainly in the appearance of flakes and, therefore, four heats of steel 40Kh were tested for flakes by means of machining specimens in steps to various depths. The results of the test showed that the replacement of ferrochromium by silicochromium and the addition of silicochromium into the ladle does not increase the flake sensitivity of the chromium steel; all steel produced conformed to the GOST requirements.

As a result of the reduction in the losses of silicon and chromium and, consequently, the reduction in the consumption of ferrochromium and blast-furnace ferrosilicon, the following average savings can be achieved with the new method of deoxidizing chromium steels: steel 20Kh-11.9 rubles per ton, steel 40Kh-4.8 rubles per ton, steel 45Kh-1.6 rubles per ton, steel 17KhN2-6.2 rubles per ton, steel 40KhN-2.7 rubles per ton and steel 15KhSND-18.2 rubles per ton.

COMBUSTION OF FUEL OIL AND NATURAL GAS IN OPEN-HEARTH FURNACES

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Fuel-Oil Firing

Owing to the shortage of coke-oven and blast-furnace gases in 1957-1958, some of the 400-ton open-hearth furnaces at the Magnitogorsk Metallurgical Combine were changed from mixed-gas firing to oil firing. The design of the furnace was not altered; the gas regenerators were utilized for heating a portion of air (30-50%). Fuel oil was fed through burners (two on each end of the furnace) mounted in the port end brickwork; from the outlet of the port a stream of hot regenerator air entered the working space of the furnace (Fig. 1). It was found that a better way of firing was by means of a burner mounted at the end of the port.

The combustion process of atomized oil, irrespective of the method of its combustion, consists of heating, vaporization, thermal decomposition, mixing with air, ignition and combustion; these stages cannot be separated from each other and frequently occur simultaneously. If fuel oil is fed directly into the working space of the furnace the preliminary stages take place in the first part of the flame and hence the intensity of combustion is lowered; unfavorable conditions for combustion are also created if a relatively large quantity of air (11-13 nm^3/kg fuel oil) spread over the whole surface area of the flame opening is dragged into the oil-and-steam stream. These are the reasons for several attempts to prepare the fuel oil for combustion and to mix it with hot air by means of the gasification of the fuel oil prior to its entry into the working space of the furnace. For this purpose it was necessary to find a convenient and efficient design of the gasifier. Charging all the fuel oil into the port (Fig. 2) provides a successful solution to this problem. The oil stream atomized by steam joins the stream of primary air heated to 1000-1100° in the regenerator. The oil vaporizes, undergoes thermal cracking and partially burns. The temperature in the port increases to 1650-1750°; the mixture of the formed fuel-oil gas and the remaining air leaves the port at high velocity, meets the stream of secondary air and forms the flame.

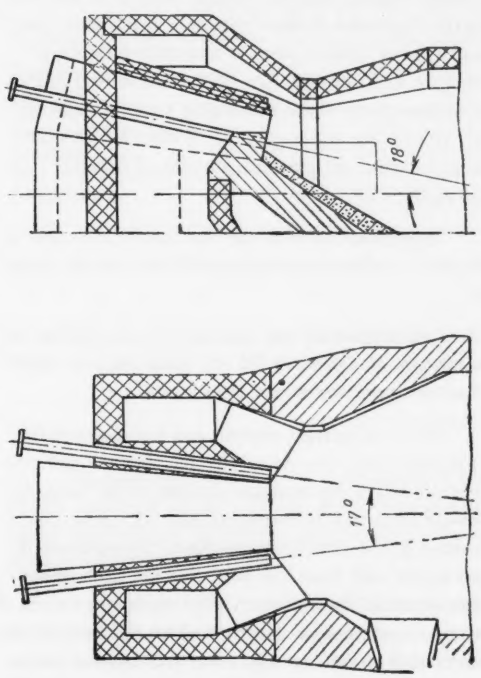

Fig. 1. Diagram showing the arrangement of burners on the sides of the port.

In this way the port is transformed into a chamber for the fuel oil gasification and preliminary mixing of the oil with a portion of the air. In addition, the port imparts the direction of flow to the hot gases.

The prepared hot mixture burns in the working space much more readily and with a high intensity. With this method of feeding the fuel oil, the general conditions for the formation of the fuel-air mixture are better than in the ordinary oil-fired furnace or in the furnace fired with mixed gas. The fuel oil meets part of the air before entering the furnace; the high velocity of the gases at the outlet of the port assists in dragging into the flame the remaining air in the working space of the furnace.

The new method of fuel-oil firing was tested in April, 1958, in a 400-ton open-hearth furnace before it was to be shut down for cold repairs. Experimental heats

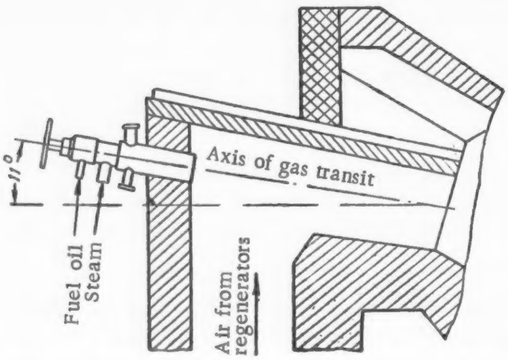

Fig. 2. Diagram showing the burner mounted at the head of the port.

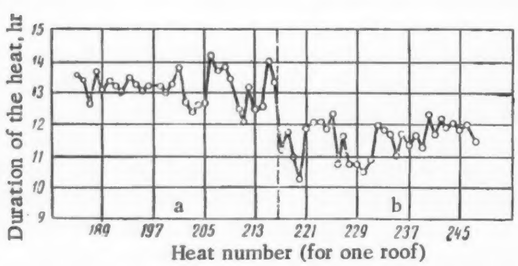

Fig. 3. The dependence of the duration of the heat on the method of oil firing; a) Burners mounted on the sides of the port; b) burners mounted at the head of the port.

TABLE 1
Operating Statistics for Different Arrangements of Oil Firing in an Open-Hearth Furnace

Item	Method of feeding the fuel oil: Side-mounted burners	Method of feeding the fuel oil: Burner mounted at the head of the port
Number of heats compared	12	12
Average duration, hr-min:		
heats	15-08	13-25
melting;	5-52	4-56
Average composition after the melting, %:		
S	0.058	0.052
C	0.65	0.89

demonstrated the advantages of this method over the method with the burners arranged on the sides of the port.

It is seen from Table 1 that the duration of the heat was reduced by 11% mainly on account of the shorter melting period. The sulfur content after the melting was slightly lower (by 10%).

During the next campaign 70 heats were carried out with burners mounted at the head of the port. Immediately after the side-mounted burners were replaced by the burners mounted in the port the duration of the heats decreased rapidly (Fig. 3).

In 70 heats the output of the furnace increased by 11.5% and the specific fuel consumption decreased by 3.6% on the average. The number of short heats (less than 11 hours) increased from 1.1 to 13.5%. At the same time it should be mentioned that no other design modifications of the furnace were made and the range of steel grades produced was the same.

Fig. 4 shows the burner which can be mounted at the head of the port. The oil is atomized with steam which attains supercritical velocity in the nozzle enlargement formed by the cylindrical surface of the steam nozzle and the conical surface of the fuel nozzle. Experiments show that this is the most rational type of nozzle since it makes it possible to achieve a high atomization of the liquid fuel with a low consumption of the atomizing medium (0.4 kg/kg). The burner is designed for 6 atm steam pressure and 2 atm oil pressure; its rate of firing is 3500 kg/hr.

Experience showed that the burner is simple in operation, works continuously and does not get clogged.

Compressed air too was used for atomizing; its low pressure (1.5-2 atm) did not bring out any apparent advantages over steam atomization.

The temperature regime and the characteristics of the flame depend on several factors: fuel consumption during the separate periods of the heat- fuel-to-air ratio; primary-to-secondary air ratio; consumption of the atomizing medium; temperature of gases at the exit from the port; and the dimensions of the outlet of the gas duct. The optimum values of these parameters were determined on the basis of the observations of furnace operation and thermal measurements.

Table 2 shows the heat distribution and gas consumption for separate heat periods.

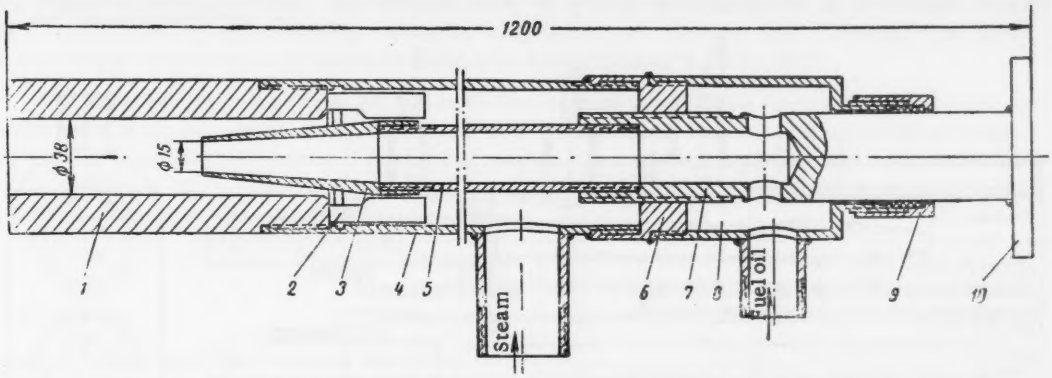

Fig. 4. Fuel oil burner (firing capacity: 3350 kg/hr) for mounting at the head of the port: 1) steam nozzle; 2) guide; 3) fuel nozzle; 4) burner body; 5) fuel tube;6) fixed screw; 7) adjustable screw; 8) oil chamber; 9) holding screw; 10) holder.

TABLE 2

Operating Data for Separate Periods

Period	Duration, hr–min	Firing rate, million kcal/hr	Fuel oil consumption, kg/hr	Air consumption, nm^3/hr	
				primary	secondary
Fettling	0—15	23.5	2500	22000	15000
Charging	2—00	28.0	3000	22000	24000
Heating	2—00	28.0	3000	22000	24000
Hot metal charging	0—30	23.5	2500	22000	28000
Melting	3—30	23.5	2500	22000	30000
End of melting . . .	1—00	25.0	2700	22000	24000
Finishing	2—45	26.0	2800	22000	23000

The average rate of firing was maintained the same as with burners mounted on the side of the port. The air rate through the old gas duct remained the same during all heat periods. The rate of the secondary air was adjusted according to the analysis of the flue gases, the excess air being maintained at 5-15%.

The shape of the flame in the working space of the furnace was very similar to the flame produced by mixed coke-oven and blast-furnace gas. However, the rate of flow of the gases from the port was higher which resulted in a better rigidity and stability of the flame, improved the heat transfer to the metal bath and provided better operating conditions for the brickwork of the working space of the furnace.

The calculated relative velocities and the energy of the flame at the exit from the port for oil-fuel and gas-fuel furnaces are as follows:

	Furnace	
	oil fuel	gas fuel
Gas velocity at the exit from the port, m/sec.	88.0	47.0
Kinetic energy of the gases at the exit from the port, kgm/sec.	476	53.5

To maintain the velocity of the gases of the fuel oil flame at 88 m/sec, the primary air rate was maintained at the maximum level (within the range of the capacity of the air fan) during the whole period of the heat. It was found desirable to reduce the exit cross section of the port to 0.05 m^2 (compared with 0.65-0.7 m^2 when side-mounted burners were used).

The temperature at the exit from the port is an important characteristic of the flame and of the gasification regime of the fuel oil. It was not possible to determine this temperature directly but an approximate estimate could be made from the measurements of the temperature of the port lining. These measurements (during the finishing period of the heat) showed that during the passage of fuel gas (oil) or flue gases the port lining was heated to the same temperature (1680°C).

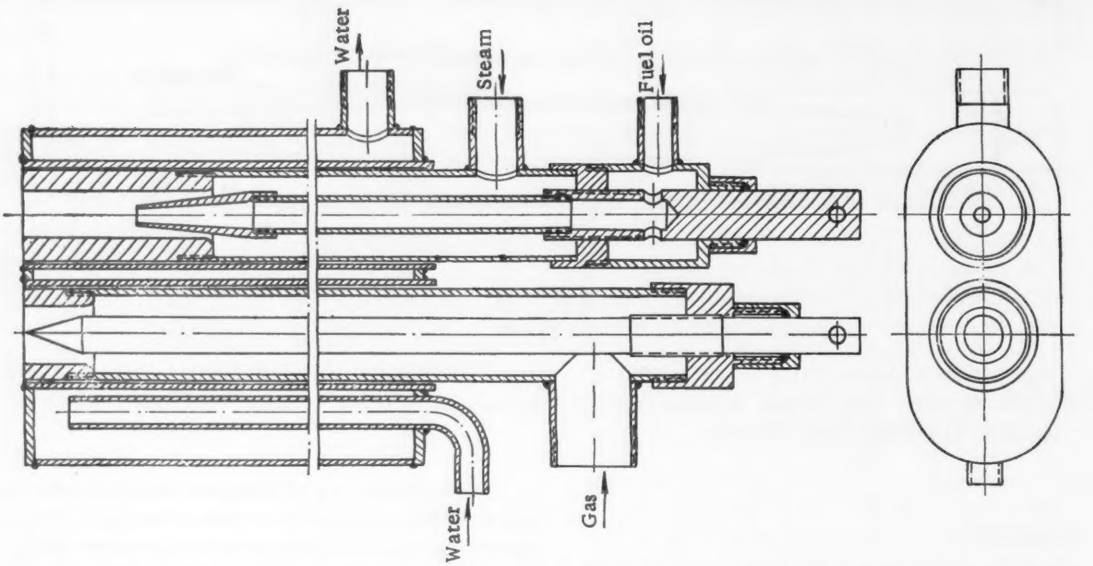

Fig. 5. Combination gas-and-oil burner with separate feed for fuel oil and gas, suitable for mounting at the head of the port.

It follows, therefore, that the temperature of the gas mixture is very close to the temperature of the flue gases inside the port, i.e., approximately 1700 - 1750°C. This value was assumed in the calculation of gas velocities.

The heat balance across the gas duct shows that the maintenance of the temperature at 1750°C requires the combustion of 25-30% of the total fuel oil inside the port. The heat of the partial combustion of the fuel oil is transferred by the hot gases into the flame and increases the flame temperature and improves its aerodynamic characteristics.

The rate of the atomizing steam has a significant effect on the length of temperature of the flame. It was found that the optimum steam rate is 0.4 kg of steam per 1 kg of fuel oil; the end of the visible part of the flame (during the finishing period) was opposite the third charging door.

When the oil is fed into the port, the absolute temperature as well as the temperature difference along the flame, increase; the thermal driving force and the heat transfer from the flame to the metal bath improve. The increase in the temperature in the working space of the furnace is a result of the improved conditions for gas mixing prior to the exit of the gases from the port as well as in the working space itself.

Fig. 6. Diagram showing the method of (a) the mounting, and (b) the design of the burner for firing natural gas only.

Change to natural gas firing. The successful firing of open-hearth furnaces with oil fed throught the port was utilized for developing a promising scheme for using natural gas. This new type of fuel came into use at the Magnitogorsk Metallurgical Combine for firing open-hearth furnaces in April, 1959.

The above two methods of firing the fuel in the furnace were employed for firing natural gas. Again, the method of firing the fuel through the port was found to be the better one. In June, 1959, one of the 400-ton furnaces was adapted for this method of firing. The design of the combination gas-and-oil burners used in this furnace is shown in Fig. 5. The parameters of the fuel oil burner were left unchanged; the gas burner was calculated for the critical exit velocity at 1.5 atm pressure.

TABLE 3

Operation of the Open-Hearth Furnace when Fired with Natural Gas.

Item	Method of gas firing: Side-mounted burners	Method of gas firing: Burners mounted at the head of the port
Number of heats compared	30	30
Average duration, hr / min:		
heats	13-36	12-24
melting	5-22	4-21
Average fuel consumption, kg per ton of steel	164.5	144.6
Composition after the melt-down, %:		
S	0.040	0.040
C	0.75	0.78

The thermal regime tested during the oil fired heats was maintained in this case too: the distribution of heat over separate periods of the heat, the fuel-to-air ratio, the rate of the atomizing medium and primary air and the dimensions of the gas duct remained the same. At the same time, it was noted that the rate of heat absorption by the charge during the charging and heating periods was higher. When the fuel oil consumed was 25-30% (in terms of total heat liberated), the sulfur content after the melting was reduced by 23% (Table 3).

The first 30 experimental heats were carried out with the addition of 25-30% (in terms of heat liberated) of oil to the fuel gas. Then, natural gas alone was used and for this purpose some modifications were made to the burners. Fig. 6 shows the location and general arrangement of the natural gas burners. The low velocity of the gas (15-40 m/sec) assists in the decomposition of the gas inside the vertical duct and the port, and contributes to the luminosity of the flame on account of the formation of carbon particles.

As a result of the success of the first experiments on the firing of natural gas through the port, other furnaces were changed to this new method of firing. Between July and October, 1959, all furnaces in the shop were changed to gas firing and were operated without the use of fuel oil. Operation with gas only has several advantages: there is no need to maintain complicated steam and oil supply systems, the fuel gas is cheaper, the sulfur content in the metal is lowered and a high rate of firing can be maintained.

At present, owing to the shortage of gas, combination gas-and-oil fuel is used. During the fettling, charging and heating periods no oil is fired, and during the remaining periods fuel oil is fired at a constant rate, constituting 8-10% of the total heat liberated.

The change to the new method of firing open-hearth furnaces made it possible to increase their output by 2.5-3% and reduce the fuel consumption by 4%.

CONCLUSIONS

The new method of firing fuel oil and natural gas with the use of the 3-way Venturi head and the charging of the fuel through the port was successfully introduced at the open-hearth furnaces of the Magnitogorsk Metallurgical Combine.

The method of firing open-hearth furnaces with fuel oil or natural gas charged through the port is more rational than the charging of fuel oil or fuel gas directly into the working space of the furnace. This method ensured a high furnace output when fired with cold gas of a high calorific value without the addition of fuel oil; fuel oil is used as an emergency fuel, but it is not essential. The change from mixed gas to liquid fuel or cold natural gas does not require any structural changes of the furnace and results in a higher furnace output.

The principle of controlling the flame by a preliminary treatment of the fuel and by mixing the fuel with hot air should be employed in standard furnaces designed for firing fuel oil and cold gas of high calorific value (with single and double ports).

A RATIONAL METHOD OF FEEDING OXYGEN TO OPEN-HEARTH FURNACE BURNERS

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Chelyabinsk Metallurgical Works
Translated from Metallurg, No. 10, pp. 19-21
October, 1960

Experience indicates that by improving the method of feeding the oxygen stream into the flame, it is possible to improve the output of open-hearth furnaces, to lower fuel consumption and oxygen consumption and to extend the service life of some part of the furnace.

Initially, at the Chelyabinsk Metallurgical Works, oxygen was introduced through two nozzles positioned on two sides of the port and inclined at 8° to the horizontal and parallel to the bottom of the port. The outlet of the nozzle was 300 mm above the bottom of the port. This arrangement of the nozzle meant that the oxygen stream could be fed into the center of the gas stream (the height of the gas stream was 600 mm). All iron and steel works in the Soviet Union employ the same method of feeding oxygen.

This arrangement of the nozzles was adopted on the basis of the study of flow in hydraulic models of an open-hearth furnace. The method which provided for the best movement of the flame in the model furnace was considered to be the most suitable. It was not possible to take into account the radiation characteristics of the flame and no comparison of different methods of oxygen supply to open-hearth furnaces on a large scale was carried out.

Observations indicate that the zone of oxygen combustion takes place in the upper part of the flame (Fig. 1) since, as a result of the rigidity of the flame it is inclined at 18-20° in 370-ton furnaces and at 15-16° in 100-ton and 185-ton furnaces. It should be mentioned that the inclination angle of the upper edge of the flame depends on the level of the bath, and the above angles correspond to the case when the slag is at the level of the main sills of the charging doors. The inclination angle of the upper edge of the flame increases when the surface of the bath falls, and decreases when the surface of the bath rises. All these results refer to furnaces operating at a high temperature and employing Venturi heads.

The oxygen stream set up at an angle of 8-9° gets outside the gas stream at a point 1.5 m away from the port and then oxygen combustion takes place in the upper portion of the flame. In this case the high-velocity oxygen stream ejects the gas stream, detaches the flame from the melt and transfers the combustion front to the upper portion of the flame; the heat flux to the bath decreases and the heat flux to the brickwork increases.

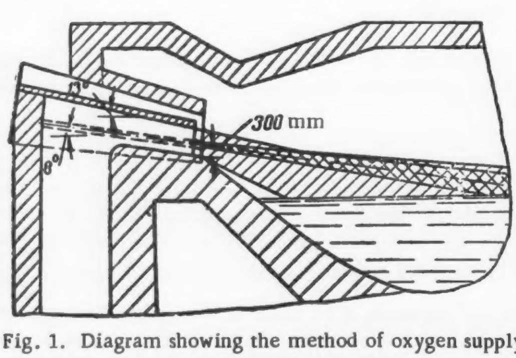

Fig. 1. Diagram showing the method of oxygen supply to the flame in the open-hearth furnaces.

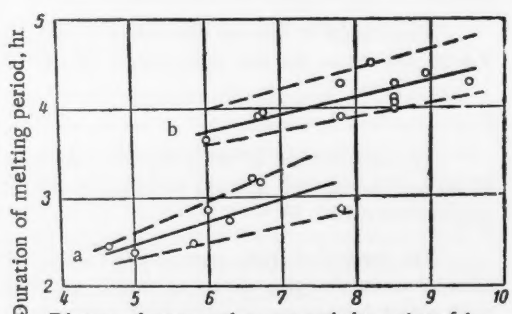

Fig. 2. The dependence of the duration of the melting period on the distance between the port and the point at which the oxygen stream impinges upon the melt; a) 185-ton furnace; b) 360-ton furnace.

TABLE 1

The Dependence of the Length of the Entry Path of the Oxygen Stream into the Melt on the Method of Feeding Oxygen

Method of feeding oxygen	Distance, m	
	between nozzle and oxygen entry into gas stream	between nozzle and intersection of the streams
Oxygen fed along and beside the port	1.36	10.4
Nozzles arranged at a distance of 150 mm from each other	1.19	6.9
Oxygen fed through the port structure	0.9	8.8

TABLE 2

Operating Statistics of an Open-Hearth Furnace

Item	Method of feeding oxygen		Results	
	on both sides of the port	through the port structure	(reduction -, increase +)	%
Duration of heat, hr - -min	7-03	6-48	-0-15	-3.5
Melting period, hr -min	1-49	1-41	-0-08	-7.3
Output ton/hr	14.0	14.4	+0.4	+2.8
Fuel consumption, kg/ton	186	180	-6	-3.2
Average heat liberation, million kcal/hr	18.2	18.15	-0.05	-0.3

When the oxygen stream is inclined at an angle of 8° it impinges upon the melt at a distance of approximately 9 m from the port [(1.25/tg 8°)= 8.9m], i.e. at a distance between halfway through and the end of the furnace. At the same time it is desirable that the gas stream should contact the melt at a distance of approximately one third of the length of the bath (approximately 5.7 m from the port in 185-ton and 370-ton furnaces). Actually, as a result of the rigidity of the gas stream this contact takes place sooner.

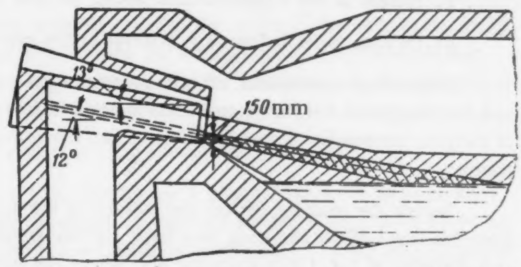

Fig. 3. Proposed arrangement of oxygen supply to the flame in the furnace.

In 1958 and 1959, the inclination angle of the oxygen nozzles and their height above the bottom of the gas duct in the open-hearth furnaces at the Chelyabinsk Metallurgical Works was changed several times. The analysis of the results of the operation of the furnaces with different arrangements of oxygen supply to the flame shows that the furnaces operate more efficiently if the point of impingement of the oxygen stream upon the melt is near the base of the flame.

The thermal effectiveness of the furnace is determined mainly by the duration of the melting period which is shortened if the heat transfer from the flame is improved (during the melting period as well as during the charging and heating periods), if the oxidizing power of the flame during the melting period is increased, etc.

It is seen from Fig. 2 that the melting period is reduced if this distance is shortened. Consequently, the duration of the whole heat is reduced and the operating statistics of the furnace improve.

The distance between the port and the impingement point of the oxygen stream is not the only factor on which the thermal operation of the furnace depends, because a certain arrangement of oxygen supply to the flame, other conditions being equal, improves the thermal operation of the furnace on account of an intensive combustion near the melt. The most desirable method of oxygen supply would be to feed oxygen under the flame, that is at the level of the port bottom and at an inclination angle approximately equal to the slope of the port bottom (9-10°). However, with this arrangement of oxygen supply, the oxygen nozzles frequently become plugged, covered with slag and fettling materials. Therefore, it is not possible to install the oxygen nozzles at a level less than 150 mm above the port bottom.

It should be pointed out that when the oxygen nozzle is lowered and its inclination angle increased, the combustion zone of the oxygen is located under the flame and this affects adversely the service life of the banks and requires a more thorough fettling of the banks.

A study of the encrustation process of the banks indicates that the encrustation begins at the air inlets which are affected more than the banks. Therefore, it is more advisable to introduce oxygen through the port structure. This will ensure that the oxygen stream will enter the gas stream early and that the streams will intersect (Table 1).

In the open-hearth furnaces of No. 1 shop at the Chelyabinsk Metallurgical Works, the intersection angle between nozzles was increased in order to reduce the spread of the flame and the distance between the nozzle and the intersection point of the oxygen streams. This improved the flame shape (but it was not possible to measure its effectiveness); owing to the increase in this angle, the flame did not spread excessively and the combustion took place inside the gas stream.

When the oxygen was fed through the port structure at one of the open-hearth furnaces an improvement in the thermal operation in the furnace was noted (Table 2).

Thus the following main conditions for feeding oxygen into the flame can be deduced from the study of the flame set-up and the analysis of the thermal operation of open-hearth furnaces;

a) Inclination angle of the oxygen nozzles: 12°.

b) Height of the oxygen nozzle above the port bottom: 150 mm.

c) Oxygen to be fed through nozzles in the port structure.

Under these conditions, after it enters the gas stream, the oxygen moves all the time inside the gas stream, and thus improves the flame operation and intensifies the mixing process of the gas and air (Fig. 3). The zone of oxygen combustion is then transferred into the lower portion of the flame and the heat transfer to the bath improves.

During the melting period, the surface of the metal in 370-ton furnaces rises, on the average, to 700-800 mm from the level of the charging door base. At the same time, the intersection point of the oxygen stream will be at a distance of 1.4-1.9 m from the port where the stream has still considerable energy and will oxidize the metal at a high rate. In addition, the oxygen stream will eject an air stream, which in turn will substantially increase the oxidizing power of the furnace and consequently reduce the melting and finishing periods.

With this method of direct oxidation of the bath, one should expect a substantially smaller dust carry-out than with oxygen blown through the roof into the bath, since the metal will be oxidized by the mixture of the combustion products with oxygen and air, and a large part of the dust will settle during the movement through the working space. This is roughly the way in which steel melters in the U.S.A. reduce the dust carry-out during the oxygen blow into the melt when they set the nozzles at an inclination toward the center of the furnace. This method improves the displacement and the operation of the flame still further. Admittedly, the commercial introduction of these nozzle tips is impeded by their rapid burning (the tips have to be replaced approximately every 10 days).

A SYSTEM OF REDUCTIONS AND ROLL PROFILES FOR ROLLING THIN STEEL SHEET IN CONTINUOUS MILLS*

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Urals Institute of Ferrous Metals

Translated from Metallurg No. 10, pp. 22-23, October, 1960.

To reduce strip tearing during rolling M. A. Leichenko suggests drawing the edges of the strip in the third, fourth and fifth stands greater than the drawing in the center of the widths. For this purpose he recommends that from the first and second stands a strip should be obtained with a double concave profile and in the subsequent stands the rolling should be carried out in rolls with a cylindrical profile barrel.

We will consider certain features of the process under these rolling conditions.

As is known, the tranverse cross section of a hot rolled strip usually has a double convex (a lens-shaped) profile. The mean transverse difference in thickness of strip intended for the cold rolling of thin steel sheet on the five stand mill of the 1200 five-stand mill of the Magnitogorsk Combine is 0.05 mm. If this strip is rolled by the M. A. Leichenko method, i.e.,strip leaves the first stand with a double concave profile of the transverse section, then the strip will have considerable waviness in the middle of the width (camber) and increased stretching of the edges. In fact, so that after rolling of 2.2 mm thick strip with a transverse difference in thickness of 0.05 mm a strip is obtained with a double concave transverse profile with a thickness in the center of 1.96 mm (a reduction of 11%) and at the edges 2.04mm, the drawing in the center of the strip should be 0.07 greater than at the edges. This means that the sections in the middle of the strip will be longer than the edge sections by 280 mm in every 4 m of strip length (the distance between the first and second stands),i.e., as mentioned above, the strip will be wavy at the center and there will be increased stretching of the edges. A similar effect but to a lesser degree will be observed in the rolling of strip with an initial flat profile in the transverse cross section.

According to Leichenko's suggestion the strip from the second stand should also have a double concave transverse cross section and it should then be rolled (in the third, fourth and fifth stands) with greater stretching of the edges relative to the middle of the strip and the double concave section gradually changed to rectangular (this is necessary in order to carry out the rolling in the last stands with the tension of the edges of the strip less than at the center). However, in our opinion, this method of deforming the metal will not achieve its purpose: the tension of the edges of the strip will always be higher than that of the center if an attempt is made to obtain a rectangular shape for the finished strip (as recommended by M. A. Leichenko) from a strip having even a double concave profile of the transverse cross section, but in addition also considerable waviness in the middle, arising in the first stand. This fact will increase the danger of the strip tearing; the rolling of thin strip becomes difficult (or even almost impossible) and, furthermore, leads to a considerable increase in the amount of thin steel sheet which is unsuitable for tinning due to waviness.

The Leichenko method is therefore not based on the condition of uniform drawing of the metal across the width of the strip in each stand and for this reason it cannot be used for the production of thin steel sheet.

As is known, in cold rolling mills the upper work rolls have a convex barrel and the bottom rolls are cylindrical. The use at the first and second stands of not only the top but also the bottom work rolls with a convex barrel, as suggested by Leichenko, will complicate the adjustments of the mill and the retention of the strip along the rolling axis.

* A discussion of the article by M. A. Leichenko "Two Methods for Cold Rolling Sheet Steel in Continuous Five-Stand Mills," Metallurg, No. 4, 1960.

TABLE 1

Reduction Systems in Stands (USA, Britain)

Number of stand	Thickness of metal, mm		Reduction per pass		Total reduction in %	Remarks
	before pass	after pass	mm	%		
1 2 3 4 5	2.25 2.0 1.08 0.67 0.43	2.0 1.08 0.67 0.43 0.25	0.25 0.92 0.41 0.24 0.18	11.0 45.0 39.0 36.0 42.0	11.0 52.0 70.0 81.0 89.0	According to the data of Powell and Kaufmann* (Iron and Steel Engineer No. 1, 1951)
1 2 3 4 5	2.12 1.65 0.95 0.49 0.35	1.65 0.95 0.49 0.35 0.25	0.47 0.70 0.46 0.14 0.10	22.0 42.5 48.5 28.5 28.5	22.0 55.0 77.0 83.5 88.5	According to the data of Polyakovskii (Sheet Metal Industries No. 311, 1953)
1 2 3 4 5	1.9 1.5 1.0 0.58 0.38	1.5 1.0 0.58 0.38 0.25	0.40 0.50 0.42 0.20 0.13	19 33 40 33 33	19.0 47.3 69.5 80.0 77.0	According to the data of Archibald (Iron and Steel Engineer No. 5, 1957)

*The system of reductions recommended by Leichenko.

TABLE 2

System of Reductions Developed by the Urals Institute of Ferrous Metals for the Rolling of Thin Steel Sheet

Number of stand	Thickness of metal, mm		Reduction per pass		Total reduction, %	Initial convexity of barrel of upper work roll, mm	Temperature difference betw. center and edges of barrel, °C		Rolling force, tons
	before pass	after pass	mm	%			work	back-up	
1	2.2	1.6	0.6	27	27.0	0.09	0	0	600
2	1.6	1.07	0.53	33	51.3	0.10	5	2	760
3	1.07	0.62	0.45	42	72.0	0.10	10	4	910
4	0.62	0.42	0.20	33	81.0	0.10	7	3	725
5	0.42	0.28	0.14	33	87.3	0.14	7	3	800
1	2.2	1.58	0.62	28	28.0	0.10	0	0	620
2	1.58	1.02	0.56	35	53.5	0.10	6	2	800
3	1.02	0.58	0.44	43	73.6	0.10	11	4	935
4	0.58	0.39	0.19	33	82.2	0.10	8	3	750
5	0.39	0.25	0.14	33	88.7	0.14	8	3	825

Note. The bottom work rolls are cylindrical.

It should be mentioned that in the Leichenko article there are no recommendations for the thermal system of operation of the rolls. An increase in the temperature difference between the middle and edges of the 500 mm-diameter work rolls by 2° and in the 133-mm diameter back-up rolls by 1° leads to a total inconvexity of the whole system of rolls by 0.04 mm. Nor are there recommendations on the rolling forces which largely determine the conditions of deformation of the metals and, consequently, the roll profile during rolling.

The distribution of reductions through the stands recommended by Leichenko and which he took from foreign practice is not related either to the initial profile of the rolls or to the roll profile during rolling. Furthermore, the systems of reductions given are not typical for foreign mills (Table 1).

The system of reductions and initial profile of the rolls during rolling of thin sheet must be considered jointly and there should be an allowance for the temperature system of operation of the rolls, the pressure of the metal on them, the transverse difference in thickness of the strip, etc. With this basis for the interconnection of the rolling parameters for thin steel sheet there should also be the condition of uniform reduction of the strip along the width, i.e., the condition of identical drawing of the middle and edges.

In 1958 the Urals Institute of Ferrous Metals, using the above conditions of deformation, developed systems of reductions and roll profiles for thin steel sheet on the 1200 five-stand mill of the Magnitogorsk Metallurgical Combine (Table 2). The results for commercial batches of thin steel sheet were reported in May 1959 in Magnitogorsk to the Scientific and Technical Inter-College Conference on Problems of Technical Progress in Rolling Production. The use of systems of reductions and rolled profiles calculated from the condition of maintaining uniform drawing across the width of the strip has made it possible to halve the amount of strip which was unsuitable for tinning due to waviness, and also to eliminate tearing of the strip due to uneven tension.

REASONS FOR BENDING OF SIDES AND FOLDING OF BLOOMS DURING ROLLING

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Magnitogorsk Metallurgical Combine
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October, 1960

Rolling in blooming mills is often accompanied by bending of the sides during rolling of the ingot on the smooth part of the rolls and by folding of the blooms during rolling in sizing rolls. This disorganizes the operation of the blooming mill and prevents automatics being used. A study of cases of bending of the sides and folding of the blooms at the Magnitogorsk Metallurgical Combine blooming mills showed the reasons for these phenomena. The roll-groove designs of the No. 3 blooming mill of the Magnitogorsk Metallurgical Combine are shown in Fig. 1.

The Effect of Bending of the Ingot Sides on the Rolling. The value characterizing the degree of bending of the transverse cross section of a rolled ingot or bloom can be conveniently taken as the difference in the diagonals of this cross section. Measurements showed that in ingots sent for rolling this difference can reach 15-20 mm. During rolling on the smooth part of the rolls the bending is always increased. Experience showed that with an initial difference in the ingot diagonals of up to 6 mm the difference in diagonals of the bloom after rolling on the smooth part of the rolls increased very little; the increase in bending of the cross section of the bloom can be explained by the action of a geometrical factor of deformation and is determined analytically by the formula:

$$\Delta d_{\text{к}} = \beta^{2n} \sqrt{\frac{H^2 + B^2}{h^2 + b^2}} \cdot \Delta d_{\text{н}},$$

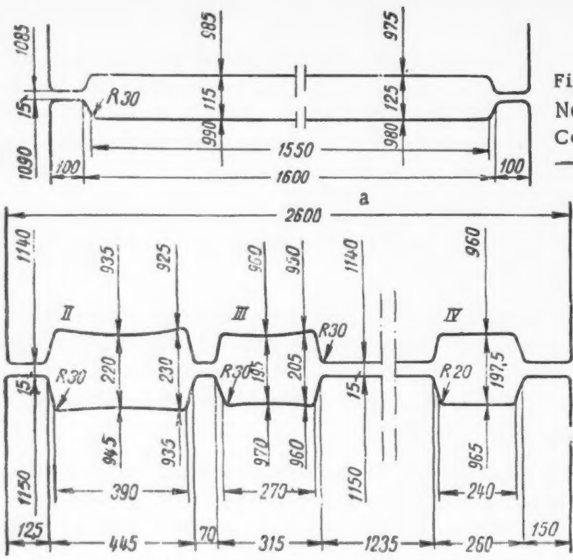

Fig. 1. Rolling arrangement and roll-groove design of the No. 3 blooming mill of the Magnitogorsk Metallurgical Combine: a) 1100 stand; b) 1150 stand.

where Δd_H is the difference in lengths of the ingot diagonals before rolling;

Δd_K is the difference in the lengths of the bloom diagonals after rolling on the smooth part of the rolls;

$\underline{n}$ is the number of manipulations;

H, B, $\underline{h}$, $\underline{b}$ are the initial and final dimensions of the bloom;

β is the mean coefficient of expansion (β = 1.02–1.03).

Calculations with this formula agreed with the practical measurements. Further rolling of blooms having a difference in diagonals after rolling on the smooth part of the rolls of not more than 10-20 mm proceeds perfectly normally.

In the rolling of ingots with a difference in diagonals of more than 6-7 mm there is a rotation (visible even to the eye) through a certain angle of the back end of the bloom. This occurs due to the absence of balancing of pressures on the metal from the side of the top and bottom rolls (Fig. 2). The tilting moment depends on the bending of the cross section in a given pass. When the bloom is turned the edges $\underline{a}$ encounter the rolls earlier than the other points of the sides; a moment is then set up which tends to turn the end of the bloom entering the rolls in the opposite direction. The relationship of the values of these moments and the moment of resistance of the bloom cross section to plastic torsion determines the posibility and value of turning in the rolls.

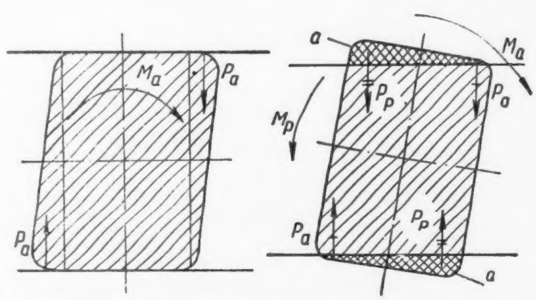

Fig. 2. Turning of bloom about the longitudinal axis of rolling.

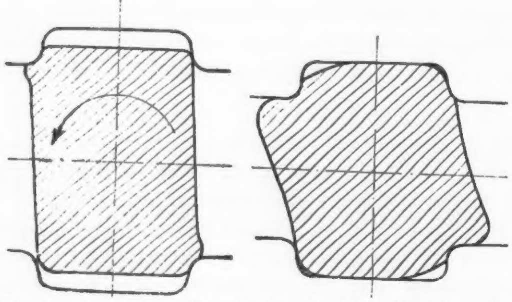

Fig. 3. Formation of "mistrimmings" and folding of blooms during rolling of bent ingots.

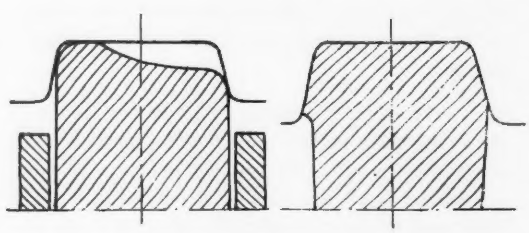

Fig. 4. Formation of "ridges" when rolling a bent bloom, held in the arms of the manipulator.

An increase in the bending of the bloom under the influence of a geometrical factor of deformation in the first passes with a simultaneous decrease in the cross section toward the end of rolling on the smooth part of the rolls may cause the bloom to turn in the rolls. After rolling these ingots on the smooth part of the rolls the difference in diagonals of the bloom often increases, reaching 80-120 mm in some cases. Further rolling of these blooms is accompanied by "mistrimming" and folding in the sizing rolls (Fig. 3). To avoid this the bloom with bent sides is held by the arms of the manipulator while it is fed into the sizing rolls. To prevent a bloom rolled in this position from falling the reduction for a given pass is reduced by 50-70%. Furthermore, with a normal value of reduction due to uneven deformation and expansion of the bloom with bent sides it is possible to have the formation of "ridges", later giving laps (Fig. 4). The table gives the usual arrangement for rolling 285 · 285 mm blooms and special arrangements used for intensive bending on the smooth part of the rolls. As a result of an increase in the number of passes and a reduction in the speed the rolling cycle increases by 20-30%.

With the introduction of strict specifications for the difference in diagonals of the molds there was a sharp reduction in the number of cases of unstable rolling. At the present time 95-98% of locally produced ingots have a difference in the diagonals of not more than 5-6 mm.

The Effect of Bloom Dimensions and the Reduction Value in Edging Passes. The bending of sides and folding of blooms occur most often in edging passes. Operating experience in blooming mills shows that the dimensions of the transverse cross section of the bloom and the ratio of the dimensions of its sides are closely connected with the permissible reduction in the edging pass on the smooth part of the rolls. It has been shown that, starting with a bloom of 380-450 mm width with a ratio of sides $H:B = 1.5-1.8$, the edging pass must be carried out in the sizing rolls. Rolling these blooms with a 90-100 mm reduction on the smooth part of the rolls is usually accompanied by bending of the cross section, which is also helped by the increase up to this moment of the bending of the bloom cross section under the action of the geometrical factor of deformation. A decrease in the reduction to 50-60 mm although it provides stable rolling in most cases is unsuitable from the point of view of production in the blooming mill. Experience shows that an increase in dimensions of the bloom (with the ratio of its sides unchanged) can increase the absolute reduction in the edging pass. Thus, the rolling of 700-800 mm wide ingots at $H:B = 1.5-1.8$ is not accompanied in the edging passes by a bending of the cross section even with reductions of 130-150 mm. An analysis of cases of bending in the sides of blooms has shown a connection between the width of the bloom B, the ratio of its sides K, and the value of the permissible reduction Δh, above which there is bending of the cross section of the bloom after the edging pass on the smooth part of the rolls:

$$\Delta h_p = (0.2-0.25)\frac{B}{K}.$$

In edging passes in correctly calculated sizing rolls the condition of stability is hardly limited by the value of reduction.

The Effect of the Elongation Value of Box Sizing Rolls. The increase in stability of the bloom during rolling in box sizing rolls is achieved by gripping it firmly in the bottom part of the sizing roll, starting with the first pass.

To improve the centering of the blooms the width of the first sizing roll in the bottom part should be 3-5% greater than the width of the bloom fed into it. Furthermore, in the first pass there should be filling of the groove with limited expansion at the bottom, this involving the use of uneven expansion at the contact surfaces. Deviation from these rules spoils the centering conditions in the sizing roll of blooms with a small bending after rolling on the smooth part of the rolls. An increase in the width of the sizing roll due to wear considerably increases the number of cases of bending of the bloom sides during rolling.

The value of elongation should first of all prevent the possibility of the grooves overfilling. With increase in the elongation there is a reduction in the gripping of the bloom in the sizing roll, which reduces its stability during rolling. At the same time with reduction in the elongation although there is increased gripping of the bloom in the sizing roll, there are more cases of falling due to deterioration in the condition of starting of the front end of the bloom in the sizing roll (especially when fed from the rear side of the mill).

In the period 1933-1936 at the No. 2 blooming mill of the Magnitogorsk Metallurgical Combine they used grooving with an elongation of 7-9%. The sizing rolls operated with overfilling and rapidly wore out. The small value of the elongation led to "mistrimming" and to falling during entry. The severe wearing of the sizing rolls caused the metal to wedge, which was the reason for the folding of the blooms during rolling. Rejections due to

Rolling of a 285 · 285 mm Bloom from a UNS - 7, 0.5 Ton Ingot of 810 · 640 mm Cross Section

Stand	Number of sizing roll	Number of pass	Ordinary			Number of pass	Special					
							with constant bending of ingot cross section on smooth barrel			with unexpected strong bending in the edging pass (8th pass)		
			cross section	Δh	Δb		cross section	Δh	Δb	cross section	Δh	Δb
1100	Smooth barrel	7	480×645	40	10	7	480×645		5	480×645		?
		8	580×500	65	20	8	620×485	25	5	580×500	65	20
		9	520×515	60	15	9	585×495	35	10	555×505	25	5
		10	460×530	60	15	10	440×600	55	15	455×565	50	10
		11	400×545	60	15	11	390×610	50	10	390×580	65	15
1150	II	1	480×420	60	20	1	580×400	30	10	550×395	30	5
		2	410×435	70	15	2	530×415	50	15	510×405	40	10
		3	365×425	70	15	3	470×430	60	15	460×415	50	10
		4	290×440	75	15	4	410×445	60	15	410×425	50	10
						5	370×425	75	15	360×425	65	15
						6	290×440	80	15	290×440	70	15
	III	5	355×305	85	15	7	355×305	85	15	355×305	85	15
		6	275×315	80	10	8	275×315	80	10	275×315	80	10
		7	285×285	30	10	9	285×285	30	10	285×285	30	10

folding reached 1.5-2.0%. An increase in elongation to 12-18% did not completely eliminate these faults. Further experience in the operation of blooming mills at the Magnitogorsk Metallurgical Combine and other plants showed that the optimum elongation for box sizing rolls of the blooming mill is 22-15%.

The Effect of Nonuniformity in Heating the Ingot and the Grade of Steel. Heating the ingots in pits is usually accompanied by a certain lack of uniformity in the heating of the ingot across its section. Pyrometric measurements showed that with intensive operation of the pits the difference in temperatures of the opposite sides of the bloom can reach 100-200°. To a large extent this is the case with ingots weighing 8-9 tons and especially ingots taking up a position in the boxes which is unsuitable with regard to the flow of heat. Nonuniform heating begins to have an effect during rolling after reduction of the ingot cross section to about 500 · 500 mm square and increases noticeably toward the end of rolling. Rolling on the smooth part of the rolls is accompanied by a noticeable increase in the bending of the sides and rolling in the sizing rolls is accompanied by a more or less intense uniform twisting or crescent-shape of the end of the bloom leaving the rolls. This effect is encountered particularly frequently at plants rolling alloy steels.

The large amount of metal rolled in small patches does not allow the heating of each steel to be sufficiently carefully finished off; furthermore, small cross section ingots are usually rolled. The effect of both these factors is that cases of bending of the sides and folding of the blooms during rolling are more frequent at factories producing high grade steels than at plants rolling ordinary carbon steels. Because of this it has been suggested that blooms of alloy steels are more inclined to bending of the sides and folding during rolling. The work of the Magnitogorsk Metallurgical Combine blooming mills and other plants producing mainly commercial carbon steels does not confirm this opinion. The heating of high grade and alloy steel ingots rolled comparatively rarely at these plants and in small amounts is carried out more carefully than that of commercial steel ingots, as a result of which the rolling of ingots of these steels is more stable. Operating experience in the Magnitogorsk blooming mills shows

that with careful heating and other conditions being equal these ingots are less inclined to bending during rolling on the smooth part of the rolls and to folding in the sizing rolls.

The crescent shape and twisting of the end of the bloom leaving the rolls is usually a sign of inefficient heating. An analysis of this phenomenon was given by I. M. Pavlov. If the heating cannot be improved efforts should be made to have a minimum number of passes of the ingot on the smooth part of the rolls.

The reasons considered above for the unstable rolling of blooms are fundamental and should be eliminated. To a certain extent the bending of the sides and twisting of the bloom during rolling are also affected by: 1) the displacement of the blooming mill rolls in an axial direction relative to one another; 2) wear and bending of the first rolls of the live roll table; 3) bending of the rolls in a vertical plane; 4) feeding the ingot "at an angle"; 5) the shape of the front end of the bloom.

The effect of the first and second factors is particularly noticeable. The bending of the rolls occurs due to wear of the pillows, bearings and causes a noticeable increase in the bending and twisting of the bloom.

Many of these factors can operate simultaneously, mutually intensifying or weakening the effect of one another, due to which it is often very difficult to determine the actual reason for instability in rolling.

THE WORKING OF ENTRY GUIDES IN SECTION MILLS

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The economic details of the working of modern high-speed small section and wire rolling mills depend chiefly on the design and the material of the entry guide equipment. Modernized equipment and high rolling speeds make it possible to work continuously on the mill during all the shifts.

High production capacity of the plant is possible only if it is reliably set up; the satisfactory working of the entry guide equipment thus has a decisive influence. Experience in the use of continuous small-section mills has indicated that ten short stoppages because of disturbances in the working of the entry guide equipment reduces shift production capacity by 10-15%. Analysis of time lost on mills in our factory has shown that up to 7% of the total working time is taken up with replacement and adjustment of guide equipment. Hence the strict requirements of rolling mill technicians as to the working of entry guide equipment are understandable.

Experience in the working of a number of home and foreign mills makes it possible to establish a dependence of the life of entry guide equipment on the material from which it is made (Table).

As can be seen from the table, the maximum life in slide guides in finishing stands is attained in wire mills No. 4 and 6.

The slide guides for mill No. 4 are made directly in the factory. After case hardening, they are chromium plated in a bath of the following composition: 1 liter distilled water, 250 g $Cr(OH)_3$, 2.5 g H_2SO_4. The bath temperature is 40° C, the current density 25 amp/dm^2 at 9v. Chromium plating lasts 30 minutes.

The slide guides for mill No. 6 are made from heat-resistant stainless steel, and their life is therefore extremely high.

Guides made from pearlitic cast iron (mill No. 1) do not give long lives, but they avoid the welding to them of the metal being rolled. Because of this valuable property, there is no objection to using them in factories.

Comparative Characteristics of the Life of Entry Guide Equipment at a Number of Home and Foreign Mills

Location of mill	Type of Mill	Stand	Diameter of section rolled mm	Type of Equipment	Material	Life before repair	
						tons	hours
USSR No. 1	Continuous wire mill	Roughing	6.5	Slide guide	Pearlitic cast iron	2700	200–220
	The same	Finishing	6.5	The same	The same	100	8–10
USSR No. 2	The same	Roughing	6.5	The same	Steel 35–502	1140	60
	The same	Finishing	6.5	The same	Gray cast iron 18-36	76	4
USA No. 3	High-speed wire mill	Finishing	–	The same	Titanium carbide inserts	–	200
USSR No. 4	Looping wire mill	Finishing	6.5	The same	Steel 3, case hardened and chromium plated	2000	75
USSR No. 5	Looping wire mill	Roughing	6–12	Slide guide	Tungsten cast iron	1300	150
	The same	Finishing	6–12	Entry roller assembly	Tungsten cast iron rollers	400	50
USSR No. 6	The same	The same	6.5 and 8	Slide guide	1Kh18N9T	9400	360
USSR No. 7	Continuous small section mill	The same	10–22	Entry roller equipment	Rollers of magnesium-inoculated cast-iron	up to 4200	70-85
USSR No. 8	The same	The same	14–32	The same	Rollers from St. 3, hardened and surfaced with high grade electrodes	1500	30
USSR No. 9	Looping small section mill	The same	Small rounds	Slide guide	Titanium-copper cast iron	–	80-100
USSR No. 10	The same	The same	10–18	The same	Chromium steel	2000	120
USSR No. 11	The same	The same	10–16	The same	Chromium cast iron	1500-2000	60-80
USSR No. 12	The same	The same	25–33	Entry 8-roller assembly	Rollers of St. U6 or U7	300	20
USSR No. 13	The same	The same	8–23	Entry 4-roller assembly	Rollers of St. Kh12F1	500	80
England No. 14	The same	The same	9.5	Entry roller assembly	Stellite faced steel rollers	10000	about 2 years
USA No. 15	The same	The same	41–65	The same	Alloy steel rollers	8000	–
	–	The same	31–37	The same	The same	6000	–
	–	The same	20–30	The same	The same	2000	–
Poland	–	The same	12.7–25	The same	The same	4000	–

Slide guides and rollers of tungsten cast iron on mill No. 5 are used in rolling high hardness steels. The cast iron has the following chemical composition:

C	Mn	Si	Cr	Ni	W
1.8–2.2	0.5–1.0	0.5–1.0	23–25	1.5	1.3–1.5

The cast iron has a Rockwell C hardness of 42-45; to raise their hardness, the guides and rollers are normalized at 1060° C, after which the hardness is 55 R_C. It is impossible to machine such a cast iron with ordinary cutting tools, and the rollers are therefore made in two layers with a soft heart of free-cutting steel.

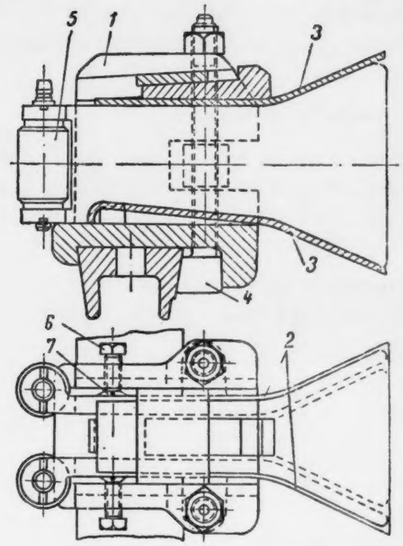

Fig. 1. Entry roller assembly. 1) Assembly; 2) guiding edges; 3) shaped plates; 4) bolt-pivot; 5) rollers; 6) adjustment bolts; 7) plate springs.

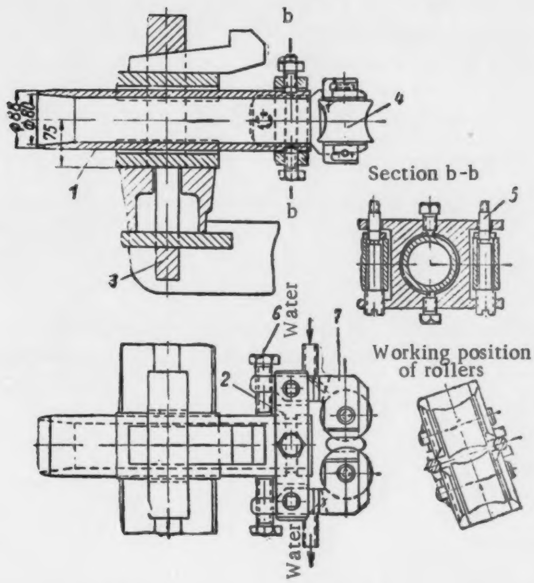

Fig. 2. Exit tilting roller equipment for a continuous small section mill. 1) Tube; 2) tilting head; 3) frame; 4) rollers; 5) movable pivot; 6) adjustment screw; 7) roller holder.

Of the small section mills listed in the table, the long life of the entry guide equipment of mills No. 14 and 15 attracts attention. The preparation of these is, however, accompanied by the use of expensive alloying elements or of special alloys difficult to obtain. Moreover, the production of such guide equipment requires the installation of small capacity furnaces for melting the special materials.

The rational solution to this problem is the use of entry roll equipment with rollers made of ordinary steels and cast iron.

On mill No. 7, rollers of a magnesium modified cast iron are installed; the life of these is somewhat lower than that of roller equipment made from expensive alloy steel.

On the roughing group of a small section in our factory roller guide equipment has been introduced with rollers prepared from ordinary steel.

The entry roller assembly (Fig. 1) consists of two guiding edges, enclosed above and below by shaped plates. The guiding edges are secured to the body of the assembly by two bolts which at the same time form pivots for them. Plain rollers for holding work-pieces of rectangular cross section are mounted in the guiding edges. The rollers are made from St. 5 and subsequently hardened; the textolite bearings (resin-impregnated fabric) are cooled with water. Adjustment bolts serve to set up the required distance between the rollers. Plate springs, situated under the adjustment bolts, protect the equipment from the impacts of the work-piece being rolled, and ensure that the leading end of the rolled product should pass through with negligible defects.

The life up to the first repair of the roller assembly described is about 7000 tons, which is ten times greater than the life of slide guides made from steel 35-502.

The rapid wear of slide guides was explained by the special conditions of the passage through them of the work-piece, which is tilted in the preceding stand.

The exit tilting roller equipment of a continuous small section mill is shown in Fig. 2. The characteristic feature of this design is the removal of the metal from the rolls through an ordinary thick-walled tube, to the

tail end of which is secured a tilting head and rollers. The tube and head are secured in a special frame, installed on the exit beam. The work-piece is tilted through the necessary angle by the rotation of the head. The rollers made of St. 5 are installed in antifriction bearings. Their position relative to the assumed plane of tilting is adjusted by the screw thread of the movable pivots. The distance between the rollers is altered by screws; this makes it possible to use the roller assembly in rolling a wide variety of profiles. The roller bearings are oil-lubricated through an aperture in the center of their spindles from a centralized system.

Cooling water is supplied to the roller surface through the body of the roller holder.

The tilting head can be rapidly and easily replaced by a new one. The life of the tilting rollers is about 12,000 tons which is 15 times greater than the life of helicoidal guides made from steel 35-502. Moreover, the use of tilting rollers does not allow the metal to weld onto the working surface of the guides and entirely eliminates surface defects (notches, scratches) which cannot be avoided with slide guide equipment.

The long life and low cost of such roller equipment with rollers made from ordinary steels and cast iron makes it possible to recommend that they should be widely introduced in rolling mills.

IMPROVING THE PRODUCTION CAPACITY OF REELING MILLS

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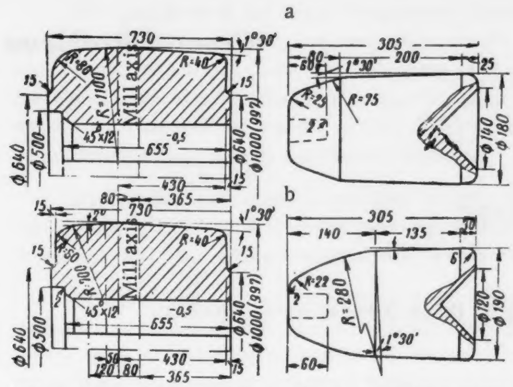
In tube rolling plant 400 there are two powerful reeling mills in the production line with the following specifications:

Roll diameter, mm:	
maximum	1000
minimum	900
Length of roll flank, mm	700
Angle of inclination of the working rolls as designed, degrees	6
Speed of revolution of the working rolls, r.p.m.	90-113
Power of electric motors:	
main drive, horse-power	1200
screw-down apparatus, kw	16
Diameter of screw-down, mm	200

The powerful screw-down apparatus makes it possible to give large reduction in wall-thickness in rolling tubes, and at the same time to reduce the variation in wall-thickness and improve tube surface quality. Therefore, the role of reeling mills as pieces of equipment determining final wall-thickness and tube surface quality is considerably raised. However, as working experience of reeling mills has shown, even with small reductions in wall-thickness they form bottle-necks in the production line, especially in rolling thin-walled tubes of large diameter. The real drawback to these mills is that the tube is fed into the working rolls by a roller-table and not by a pusher. Because of this there have been many instances of the tube's not being gripped by the working rolls; the tube had to be fed several times into the mill, as a result of which it cooled a good deal (especially its leading end), which led to an increase in wall-thickness variation, a surface of poor quality, increased consumption of electric energy and of replacement equipment.



The design of the working rolls of a reeling mill. a) Old design; b) new design.

To improve the gripping conditions, redesign of the working rolls was carried out. Following the old design (to the Gipromez * design) the angle of the entry cone (see figure, a) was made with a radius R= 1100 mm; in the improved design (see figure, b) the entry cone consists of two parts: the first (considering the rolling direction) is made with a radius R= 700 mm so that the tube is better guided into the rolls; and the second part, contiguous to the first, was made conical with an angle of taper of 2°.

Corresponding to the shape change of the entry part of the rolls, a change in shape of the Reeling mill mandrels was made: the length of the rolling part was reduced, and the leading part of the mandrel was made to a radius. However, the redesign of the working rolls did not entirely solve the problem of gripping the tube and reducing machine time rolling.

The production capacity of Reeling mills may be raised by shortening machine time and ancillary operations.

Therefore, to shorten the machine time taken in rolling, in our factory the angle of inclination of the working rolls was increased from 6 deg to 7 deg 30 min.

In the table, figures are set out for the reduction in the machine time taken in rolling tubes, resulting from a change in the angle of inclination of the working rolls.

Dependence of the Machine Time Taken in Rolling Tubes on the Angle of Inclination of the Working Rolls

Tube dimensions, mm	Machine time, sec	
	angle 6°	angle 7° 30'
168×8	31.38	27.09
219×8	30.16	25.79
273×8	34.5	28.15
325×8	49.94	38.10

In this way, increasing the angle of inclination of the working rolls in reeling mills raised the rolling speed and eliminated the bottle-neck in the production line. Moreover, after the automation of the front and rear tables of Reeling mills, the time of ancillary operations was markedly reduced.

As a result of the measures taken, it became possible to work with larger reductions; this is important in obtaining high-grade thin-walled tubes.

In planning new reeling mills, it is certainly necessary to regulate the inclination of the working rolls while keeping the speed of rotation constant.

* State Institute for the Design and Planning of Metallurgical Plants.

CONTRIBUTIONS TO INCREASED PRODUCTIVITY

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The Permanent Productivity Councils play an ever-increasing part in the management of industrial undertakings. Under the guidance of trade union organizations, these councils work out organizational and technical methods aimed at increased output, improved quality, and lower cost of production. The participation of the vast majority of workers in the activities of the councils ensures their success.

At the establishments of the metallurgical industry in the Sverdlovsk Province, there are 609 Permanent Works and Shop Productivity Councils with 26,500 members, including 83% manual workers. The metallurgical workers in the Chelyabinsk province elected 14,770 members to the 320 Productivity Councils; the majority of elected members are manual workers. In the Dnepropetrovsk Province more than 19,000 men were elected members of the Productivity Councils. 200 Productivity Councils at metallurgical establishments of the Stalino province have a membership of more than 12,000 workers, engineers, and technologists.

Recently, the Central Committee of the Trade Union of Metallurgical Workers arranged regional conferences in Stalino and Sverdlovsk with the object of exchanging views and experience on the activities of the Permanent Productivity Councils. These regional conferences were attended by leaders of Republic, regional, provincial, town, works and mining committees of the Trade Union, chairmen and secretaries of Productivity Councils, managers of metallurgical establishments, and representatives of departments concerned from the National Economic Councils.

Those attending the conference heard lectures and talks on the activities of Permanent Shop and Works Productivity Councils, about the guidance provided by the Trade Union Committees, about the experience of works managers and the introduction of approved suggestions into practice. From the lectures and exchange of views, one can conclude that in a relatively short time (just over two years) the Productivity Councils began to play an important part in the solution of industrial problems. Recently, the Productivity Councils have consolidated their position further; they have established new activities and extended their old ones, they have shown more independence in their work, and they have begun to tackle and solve difficult industrial problems with great confidence.

In only a short period of time the Productivity Councils of the Sverdlovsk metallurgical establishments considered over 7,000 important productivity problems and recommended more than 26,000 suggestions for their solution at their meetings. So far, about 80% of these suggestions have been put into practice. At the Dnepropetrovsk metallurgical establishments the Productivity Councils recommended the introduction of over 19,000 suggestions.

Productivity Councils together with Trade Union Committees at several establishments are searching for new ways and more efficient methods of operation, study, and making use of the experience of Productivity Councils of other establishments. For this purpose they arrange visits to other works, exchange information, issue new publications, and make use of other means for the exchange of experience.

The Productivity Councils of the Petrovskii, Chelyabinsk, Voroshilov, Dzerzhinskii, "Krasnyi Oktyabr", Nizhne-Tagil, and other works have brought and continue to bring, many interesting aspects into their activities. Under the guidance of the Trade Union Committees, these Councils have developed a definite style in their work and they arrange all their activities in accordance with plans approved by the Trade Union Committees.

The presidium of the Works Productivity Council at these Works cooperate closely with the Shop Productivity Councils. There are frequent cases when, on the initiative of the presidium of the Works Council, a meeting of the shop Productivity Council or of a group of Shop Councils, is held. For instance, at the Petrovskii Works the Works Council established a strict supervision of the progress and quality of new metallurgical project constructions. This problem was the subject of discussion at the Works Productivity Council and at the joint meeting of the Productivity Council and the constructors.

By assisting these councils and their Presidia in their every-day activities, the Trade Union Committees at these works insist on regular conferences and serious preparation of the problems before they are put forward for discussion, and also require a strict check on the carrying-out of all decisions.

However, the regional conferences did not deal with successes only. Several speakers have expressed anxiety and concern that at several establishments and at many shops, even at those where considerable experience on the work of Productivity Councils has been accumulated, serious shortcomings and misinterpretations of the Rules of the Permanent Productivity Councils occur, which in the end impede and delay the participation of workers, engineers, technologists, and staff in the industrial management.

A thorough analysis of the serious shortcomings in the work of these bodies was made at the two regional conferences by the Chairman of the Central Committee of tne Trade Union of Metallurgical Workers, V. A. Podzerko, who stressed the following most important shortcomings.

1. The Committees of the Trade Union and the Presidia of the Permanent Productivity Councils at some establishments and at several shops do not have a clear-cut planning of council work. As a result, in several cases the sessions of these bodies are arranged irregularly, only about two thirds of the elected members take part in their activities, and the problems brought up for the discussion are not properly prepared.

2. The Committees of the Trade Union and the Presidia for the Productivity Councils still do not attach enough importance to the follow-up and control on the carrying out of the accepted recommendations. At some establishments it is considered that arranging and holding a meeting on an important industrial problem means that the problem has been solved, although in fact it is only the beginning of the work on the way to a solution. At several establishments and shops the Presidia of the Productivity Councils do not in fact constitute a permanently acting body which should check how the decisions of the Council are carried out and should prepare the agenda for the next meeting.

3. At several establishements the Presidia of the Productivity Councils transgress their rights, attempt to take the place of the Councils, and very frequently consider problems and make decisions which should be the sole responsibility of the Productivity Councils themselves.

All these shortcomings spring from the unsatisfactory leadership of some Trade Union Committees in the work of the Productivity Councils. Some provincial Trade Union Committees arrange too few informative meetings and conferences for the exchange of experience in the work of the Productivity Councils; they do not consider the problems arising from the activities of the Productivity Councils frequently enough and do not request the leaders of industrial establishments to adopt the suggestions recommended by the Councils.

During the first half of this year, only one meeting of the Productivity Council was held at the Sinarsk Trubnoi Works. At this meeting, which dealt with the problem of the rational utilization of electric power and fuel, only 41 out of the 125 members of the Council were present. This sort of thing became a pattern in the work of the Sinarsk Productivity Council. At a meeting of the Productivity Council held at the end of last year, to consider the planning of organizational and technical innovations at the Works for 1960, only 53 members (42%) were present.

Such examples are not exceptional. Thus, for instance, the Productivity Council of open-hearth shop No. 1 at the Kirov Works in Makeevka meets infrequently (last year they met only twice, and this year only three times) and, furthermore, the meetings are never fully attended. As a rule, out of 120 members, only 30-60 attend the meetings.

At the Revda Metallurgical Works, the meetings of the Productivity Council are also arranged infrequently. The agenda for the meeting are badly prepared and, therefore, even the members do not care to attend the meetings. Thus, in March, 1960, only 38 our of the 85 members were present. Nobody contributed to the discussion

on the problem "The economy of nonferrous metals." In June, 1960, a meeting was cancelled because of inadequate attendance.

The Productivity Council at the "Azovstal'" also hold their meetings infrequently. Here, from October, 1959 to April, 1960, the Works Productivity Council did not meet at all. The same applies to the Alapaev Metallurgical Combine. The Works Council at the Zaporozhe Ferroalloy Works actually does not operate at all.

The Presidium of the Works Productivity Council of the Stalino Metallurgical Works has "rationalized" its work very substantially. The Works Council hardly ever meets. In 1959, only three meeting of the Works Council were held, and from September, 1959 to May, 1960 not a single meeting was held. On the other hand, the Presidium of the Works Council took over, as it were, the whole work. It meets once, and sometimes twice, a month and puts on the agenda and decides on its own, such problems as: "The plan for economic training of engineers and technologists," "The organization of engineering services at the Works," "The results of the application of natural gas to the production of conversion pig iron and the prospects for the adoption of natural gas in the production of special pig iron," "The economic effect of organization and technical measures, research and development work," "Approving the recommendations regarding the economy of nonferrous metals at the Works," "The work of the Productivity Councils of the Open-hearth and Rail Shops at the Works," etc.

It is not only the content of the problems brought up for discussion which indicates that the Presidium attempts to take over the functions of the Works Council. The form of the resolutions bears witness to this fact too. The administrative, commanding tone of these resolutions which usually start with the words "It is required . ." "We request . ." "We reprimand . ." etc., is incompatible with the duties and function of the Productivity Council at the establishment.

As a matter of fact, the tendency to adopt a commanding tone in the resolutions of the Productivity Councils and their Presidia is not only apparent at the Stanlino Works. This sort of thing also occurs at the Dzershinskii and some other Works.

At several establishments the resolutions of the Works Productivity Councils are carried out quite unsatisfactorily. In 1959, at the metallurgical establishments of the Chelyzbinsk Province, 1448 suggestions, i.e. 22% of all the suggestions proposed by the Productivity Councils, were not put into practice.

During last year in the Sverdlovsk province, 8500 suggestions, or approximately one third of all suggestions passed by the Works Councils in 1959, were not put into practice. At the Nizhne-Tagil Combine alone, 662 suggestions which had been put forward were never introduced.

All this is far from a complete list of all the concrete examples of vital shortcomings in the work of Productivity Councils and of unsatisfactory guidance on the part of the Trade Union Committees.

The Presidium of the Trade Union Central Committee has examined the results of the exchange of views on the work of Productivity Councils and has passed a concrete resolution in which an extensive program aimed at the elimination of the shortcomings and at an improvement in the acitivities of Productivity Councils and in guidance on the part of the Trade Union Committees was outlined.

An improvement in the work of Productivity Councils at metallurgical establishments will be a worthy contribution by the Trade Union organizations to the efforts to produce more steel over and above the target and to complete the Seven-Year Plan ahead of schedule.

THE REORGANIZATION OF THE WORK OF THE PRODUCTIVITY COUNCILS HAS SHOWN GOOD RESULTS

A. P. Egorichev, Chairman of the Metallurgists' Union Works Committee

Kuznetsk Metallurgical Combine
Translated from Metallurg, No. 10, pp. 34,
October, 1960

At the beginning of 1958 at the Kuznetsk Metallurgical Combine,40 Permanent Shop Productivity Councils and one Works Productivity Council were set up. About 3000 workers, engineers,and technicians became members of these Councils.

The Works Productivity Council has 345 members (65% workers and 35% technical staff).

The best people at the Kuznetsk Metallurgical Combine, outstanding workers and members of the Teams of Communist Labor, were elected to the Productivity Council: M. T. Kuznetsov, a steel melter at the open-hearth shop, I. D. Skorobogatov, a rolling-mill operator at the rail mill, N. K. Korolev, a senior furnace attendant at the section rolling-mill, I. I. Ivanik, a mold-maker at the casting shop, and several other workers.

The Works Productivity Council meets regularly every three months.

During 1959 and the first five months of 1960, the Council dealt with the following problems: the tasks of the Kuznetsk metallurgical workers in connection with the fulfillment of the plan and obligations regarding the lowering of production costs in 1959; measures to be taken to achieve the additional production target in pig iron, steel, rolled product, sinter,and iron ore; the state of the repair shop and spare parts stock at the Combine and the methods of improving the repair shop efficiency; the quality of the products of the Combine; the reduction of the production costs; the improvement in the running cost of the Combine.

More than 1500 workers attended the meetings and 49 members put forward suggestions and made critical remarks. Every meeting was carefully prepared; at its meeting the presidium selected and approved the composition of corresponding committees which had to study the problems to be discussed, consult the workers at the shops,and prepare concrete proposals.

As a result of the discussion of the above problems in 1959 at the Works Productivity Council,204 suggestions and organizational and technical measures were approved; 80 of these were not put into practice in the same year and a time table for 1960 has been worked out for the remaining ones. As a result of adopting these suggestions the Combine achieved an annual-meeting saving exceeding 15 million rubles.

In accordance with the resolution of the Works Productivity Council, a rail-car heater was designed and built which improved the unloading conditions during the winter season and made it possible to reduce the rolling stock delay penalties by 700,000 rubles.

On a proposal accepted by the Works Productivity Council, the reconditioning of rolls by hard alloys has been extensively adopted in the rolling shops; as a result, roll consumption in 1959 was reduced by 11% which is equivalent to a saving of one million rubles.

In the bed workshops, comrade Kovalskii's suggestion on the mechanization of the painting of bedsteads and nets made it possible to make 11 workers available for other duties, to make the work of the painters easier, and to reduce pain requirements;and this resulted in a saving equivalent to approximately 150,000 rubles per year.

The Works Productivity Council considered and approved the proposal of the workers of the blooming shop regarding the enlargement of the soaking pits. On the initiative of the innovators Pryakhin, Tarabanov,and Bidul, 7 groups of soaking pits have already been modified, and each pit can now accept 8 instead of 7 ingots. The adoption of this proposal made it possible to supply the blooming mill with well-heated ingots, to increase the output of the mill,and to improve the quality of the metal; savings resulting from the adoption of this suggestion amounted to more than 3 million rubles per year.

In the open-hearth shops, on a suggestion put forward at the Works Productivity Council comrades Chuvikovskii, Lyulenko, Zaslavskii, and others, remote control of the ladle stoppers has been introduced and thus heavy manual labor in this section has been eliminated. As a result, 8 workers have been made available for other duties and a saving of 100,000 rubles has been achieved.

In the tin-plating shop, the adoption of a pneumatic skimmer to take zinc oxide from galvanizing tanks made it possible to eliminate manual labor. This problem was solved by innovators Ivanov, Veselov, and some others. The saving resulting from this improvement constituted 100,000 rubles.

On the proposal of the Works Productivity Council a "Saving Month" was held. During that month 15,000 suggestions were made. 634 of these suggestions were put into practice in 1959 and resulted in a saving of 5.5 million rubles.

During 1959 and five months of 1960, 40 Shop Productivity Councils held 423 meetings, attended by more than 20,000 workers, at which 2,900 people came forward with new suggestions.

At Shop Productivity Councils, the problems of increasing the operating efficiency, lowering the production costs, improving the quality of the product, improving the work of innovators and inventors, introducing comprehensive mechanization and automation, and some other problems, were discussed.

More than 3,600 suggestions, of which 1,900 have been introduced and have resulted in a saving of approximately 8 million rubles, were proposed by the Shop Councils. The works of the Productivity Councils is also well organized at the Section Rolling Mill (the chairman of the Shop Committee is A. N. Vznuzdaev, and the chairman of the Productivity Council is A. D. Babushkin), at the Electric Steel Shop (the chairman of the Shop Committee is D. D. Fudkomaz, the chairman of the Shop Productivity Council is A. I. Mesyats), at the Casting Shop (the chairman of the Shop Committee is P. I. Ivanov and the chairman of the Shop Productivity Council is A. I. Permyakov), and at some other shops.

The activities of the Productivity Councils during the last year have shown that the reorganization of the Councils' work was of significant importance. The Productivity Councils have actually become a management school for the workers. The staff of the Works takes an active part in the proceedings of the Councils and has put forward many suggestions. Some of these suggestions are obviously valuable, some are questionable and require additional study; but there is not doubt that a serious approach to the operation of the Combine has become common to most of the workers and that there is a general desire to improve its operation.

SOVIET METALLURGISTS ARE DEVELOPING AND IMPROVING INTERNATIONAL RELATIONS

Yu. V. Khitsenko, Head of the Department of International Relations of the Central Committee of the Metallurgical Workers Trade Union

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The struggle for the peaceful coexistence of different social systems and for peace and friendship between nations constitute a general line in the foreign policy of the U.S.S.R. and all countries in the socialist block. This struggle is supported and approved by ordinary people all over the world.

Every honest worker in every country is pleased with the successes of the Soviet Union in science and technology and in the development of the socialist economy and culture.

The General Secretary of the Metallurgists Trade Union in Indonesia writes in his letter to Soviet Metallurgists; "On behalf of all the members of our Trade Unions we send you our best wishes.

"We hope that all the efforts of the workers in your country - the pioneers in building the socialist system - will get support from workers in other countries in their struggle to establish the socialist system. We think that you will have great success in your tremendous task of completing the Seven-Year Plan approved by the 21st Congress of the Communist Party of the Soviet Union. The success of the socialist countries will demonstrate to the whole world the advantages of the socialist system over the capitalist system."

The relations between the Soviet people and workers in foreign countries are developing and improving continuously and constitute an important contribution to the victory of progressive and peace-loving people all over the world.

The Central Committee of the Metallurgical Workers Trade Union, the Trade Union organizations,and personnel of metallurgical establishments in the Soviet Union keep in touch with similar trade unions in more than 40 foreign countries, including all the countries of the socialists block as well as Belgium, Austria, France, Luxemburg, India, Canada, Chile,and many others.

In 1959 alone, the Central Committee of the Trade Union received 692 letters and telegrams from abroad and sent out about 2000 letters and telegrams to metallurgists abroad.

In their correspondence with trade union organizations and active trade unionists in the socialist-block countries, Soviet metallurgists tell about their experiences in trade union and industrial work, about the achievements of the personnel at their works, and the successes of shock workers and Teams of Communist Labor.

In a letter to their colleagues in Ukhan (China) the Kutnezsk metallurgists say; ". . . We shall definitely fulfill our obligations. Our excellent workers at the Combine constitute the best guarantee of our success. More and more of our workers join in the competition for the title, the following three conditions must be fulfilled: 1) One has to work efficiently and economically, and introduce new techniques with perseverance and adopt every advanced and progressive method; 2) One has to improve one's industrial knowledge, master the Marxist theory,and improve one's education continuously; 3) One has to develop the best qualities of a member of a new society, attain a high and well-balanced intellectual and physical standard, be an example in social behavior and in one's duty to society." Concluding their letter, the Kutznetsk workers asked their Chinese colleagues what forms of competition there are at the Ukhan Combine, who holds the first place in the competition,and how the workers at the Ukhan Combine live, work,and study.

Frequent mutual visits of various delegations assist in improving relations between Soviet and foreign metallurgists. Here is one interesting example. Miners of the Kosice district (Czechoslovakia) visited the Krivoi Rog mines in 1958 and exchanged their views on trade union and industrial work with the Krivoi Rog workers. In 1960, a group of Krivoi Rog miners led by the Chairman of the Krivoi Rog Miners Union, Comrade Koval, paid a return visit to the Kosice miners. The visitors saw the mines, studied the production organization, and decided to adopt some of the advanced equipment used by the Czech miners, such as pneumatic pushers for car unloading, the roller pantograph for electric cars, and 100 mm cavity inserts in the explosive charges to economize explosives. On the other hand, the visitors gave their Czech friends at the Anna Mine specimens of water sprayers and pneumatic pistols for fire blasting.

As members of trade union delegations,the staff of the Kuznetsk Metallurgical Combine visited East Germany, Hungary,and China. A number of workers, technicians,and engineers took part in the opening of iron and steel works in China, Poland, and Czechoslovakia. At present the Kuznetsk metallurgists are in correspondence with their Chinese, Polish, Hungarian, and German colleagues.

Some difficulties are encountered in establishing relations with workers in the U.S.A., Western Germany, Great Britain, Sweden, Norway,and some other capitalist countries. The reactionary trade union leadership in these countries prevents their members from communicating with Soviet workers in all sorts of ways. But inspite of all the difficulties, the workers find ways of getting in touch with their colleagues in the Soviet Union. They send us letters in which they describe their hard working conditions at capitalist industrial establishments and express their admiration for our country.

Here is what one of the active trade unionists in Western Germany wrote to us: "I heard on the radio today that your scientist succeeded in sending a rocket to the moon. I am a simple man and it is difficult for me to appreciate this enormous achievement, but I realize,nevertheless, that this achievement opens undreamed of prospects for all mankind. Allow me to send you most heartfelt congratulations on the occasion of this magnificient achievement. I wish you further success in your work. In your success I see not only a proof of the hard work and perseverance of your people, but also a proof that you have chosen the right way, although this fact is not accepted by many in my country."

Visitors from capitalist countries who succeed in getting to the Soviet Union have every opportunity to acquaint themselves with the achievements of the Soviet people and can compare our life with life in capitalist countries. It should be mentioned that, although there are people of various political, philosophical,and religious views among the visitors, after the visit all of them usually speak approvingly and even with emotion about what they have seen. Thus, for instance, the delegates from the Rheinhausen A. G. Iron and Steel Works (West Germany) who came to the U.S.S.R. in April,1960, gave the Central Committee of the Trade Union of Metallurgical Workers a book about the death camp in Buchenwald with the following inscription: "The victims of fascism appeal to our conscience and put us under an obligation to dedicate all our efforts to the struggle for preserving peace. We shall fight to prevent German militarism ever again causing a disaster to the German, or any other, nation. Our visit to the U.S.S.R. made us firm friends of the Soviet Union and confirmed our belief that peace and international friendship are dear to the Soviet people. When we come back home we shall report our impressions truthfully and we will make every effort to strengthen and further German-Soviet friendship."

Indeed, upon their return the German delegation reported honestly what they had seen in the Soviet Union. But what was the reaction of the leaders of the German Socialist Democratic Party? At the conference of the German Socialist Democratic Party of the Nieder Rhein Subdistrict, Paul, Otto,and Fritz Matuls and Kurt Bethe were expelled from the Party, Willi Mühler was expelled a little later. And so five people were expelled from the Socialist Democratic Party simply because they had visited the U.S.S.R. and had the courage to tell the truth about our country. These acts of the right wing leaders of the German Socialist Democratic Party show the value of capitalist "freedom" which receives so much attention from these leaders together with Chancellor Adenauer and his colleagues.

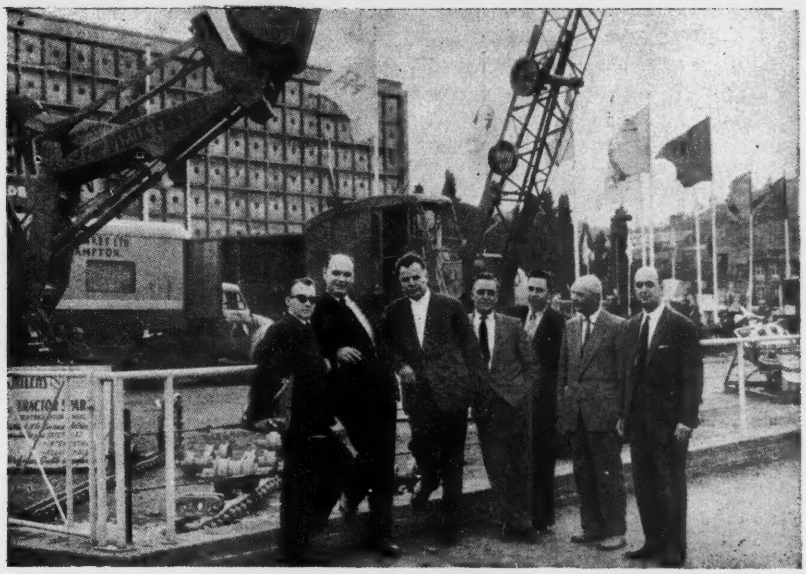
The trade union organization of Soviet metallurgical workers should continuously strive to strengthen and develop friendly relations with foreign trade union organizations and plant personnel. The resolutions of the Vth Congress of the Trade Union of Metallurgical Workers refer in particular to the need for more work in this direction by the Central, Republican, Provincial, Town, Works,and Mine Committees of the Trade Union.

Complete support should be given to strengthening international unity and solidarity in the struggle for peace, reducing international tension, and establishing democracy and socialism. The correspondence with people abroad, activities of Soviet visitors abroad at workers' meetings, contributions to the press, talks on the radio and television,are of great importance in this work.

The work of the personnel of many metallurgical establishments, of individual workers and active trade unionists who maintain correspondence with sixty foreign industrial establishments in the same branch deserves mention.

A lively and pertinent correspondence is maintained by the Trade Union Committees of the "Zaporozhstal'" Works, the K. Liebknecht Tube Works, the "Krasyni Okt'yabr" Works, the Kuznetsk Metallurgical Combine, and other establishments. The "Zaporozhstal'" Works alone maintains correspondence with 42 industrial establishments in 30 countries, and the personnel of the "Krasnyi Okt'yabr'" Works - with 19 establishments in 12 countries.

In 1960, with the object of intensifiying this work,the Trade Union Committee at the Kuznetsk Metallurgical Combine considered the problem of international relations. At the meeting of the Committee the past achievements were noted and new activities were planned. It was resolved to keep records of international correspondence and to avoid any delay in replying to letters from abroad. It was decided that every worker coming from a visit abroad should present a report to the personnel of the plant of his visit. Plans were made to devote more space in the Works Newspaper to the publication of information on visits abroad made by Soviet metallurgists. The House of Technology was instructed to prepare a map illustrating the international relations of the Kuznetsk workers. A conference with personnel who were to go abroad was planned in order to strengthen correspondence with foreign industrial establishments.



Delegation of Soviet metallurgists and mechanical engineers at tne industrial exhibition in Liege, Belgium. June, 1960.

Delegation of Czech metallurgists at the "Azovstal' " plant. May, 1960.

Members of the Bolivian delegation of miners visiting workers of the Central Committee of the Metallurgical Workers Trade Union. Moscow. May, 1959.

Members of the Trade Union Committee of the Makeev metallurgical plant and the Polish delegation of metallurgists engaging in discussion. October, 1959.

The Trade Union Works Committee set up a permanent group of 9 members to conduct the work related to the development of friendly international relations. Similar groups were also set up at the Pervo-Ural Novotrubnoi Works, the "Krasnyi Oktyabr" Works, the Karl Liebknecht Mine (Krivoi Rog), and several other establishments. The formation of such groups was initiated by the Trade Union Works Committee of the "Zaporozhstal'" Works.

The Trade Union Central Committee considered and approved the report of the Trade Union Works Committee of the "Zaporozhstal'" Works on strengthening and developing international relations.

They give practical assistance "on the spot", staff members of the Trade Union Central Committee visited the "Krasnyi Oktyabr'" Works, the Kirov Works in Makeevka, the Stalino Metallurgical Works, the "Azovstal'" Works, the Krivoi Rog mines, and other establishments. Conferences of all chairmen of Works and Mine Committees of the Trade Union of Metallurgical Workers were held at Stalino and Sverdlovsk.

It is planned that in the near future a meeting of the Presidium of the Trade Union Central Committee should consider the report of the Leningrad Provincial Committee of the Trade Union and check how the instructions of the Presidium of the Central Committee regarding the strengthening and developing relations with trade union organizations and workers in China, East Germany, and Czechoslovakia have been carried out.

One cannot overlook the fact that some Trade Union organizations do not attach due importance to this work, show a lack of interest in foreign correspondence, do not take the initiative in establishing regular correspondence with trade union organizations abroad, do not make use of international visits to obtain new addresses and establish correspondence, and have not set up special groups for this work. Among such Trade Union Committees are the Works Committee at the "Azovstal" Works, the V. I. Lenin Saratov Works, the Verkh Isetsk Works, the Yuzhnoi Ore Beneficiation Combine, and some other plants.

The Trade Union Central Committee pays a great deal of attention to international exchange visits. During 1959 and eight months of 1960 the Central Committee received 12 delegations of metallurgists and miners from Czechoslovakia, Poland, East Germany, Bolivia, Austria, France, and West Germany who visited the "Zaporozhstal'" Works, the "Azovstal'" Works, the Zakavkaz Metallurgical Works, the Kirov Makeevka Works, the Karl Liebknecht Tube Works, the Dzerzhinskii Works, the "Krasnyi Viborzhets" Works, the Voroshilov Works in Leningrad, and some other Works. The visitors has an opportunity to see the working and living conditions of Soviet metallurgical workers, to meet workers and trade unionists, to exchange views on trade union and industrial work, and to visit rest homes and sanatoria.

Before the end of 1960 our Trade Union expects delegations from Bulgaria, Korea, China, and some other countries.

Soviet Trade Union delegations visited Bulgaria, Poland, Czechoslovakia, Yugoslavia, and Belgium. Many of our trade unionists went abroad with combined delegations sponsored by the All-Union Association of Trade Unions.

It is essential for our Trade Union Central Committee to play an even more lively part in the activities of the International Federation of Metallurgical Workers Trade Unions. We should make the achievements of Soviet working people better known among metallurgists abroad and strengthen the international solidarity of the working class in every possible way in the struggle for the high ideals of all mankind.

THE PRODUCTION OF TIN PLATE IN GREAT BRITAIN

V. A. Paramonov

NIIKhIMMASh

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In recent years, two new works, the Trostre Works and the Velindre belonging to the Steel Company of Wales and specializing in the production of tin plate, in particular electrolytic tin plate, have been built in Great Britain. The Velindre Works, built two years after the Trostre Works, has no hot -dip tinning equipment. In the near future it is intended to bring electrolytic tin-plate production in England to 90% of the total tin-plate output.

The equipment of the new British Works consists of five-stand cold-rolling mills, a continuous electrochemical cleaning line, a continuous annealing line (Velindre Works), bell furnaces,and two-stand finishing mills. The process line includes uncoiling equipment upstream of the electrolytic tinning, and sheet cutting equipment upstream of the hot-dip tinning (at the Trostre Works), then electrolytic and hot-dip tinning units,and finally packing and storage sections.

A rational lay-out of the equipment is conventient for operation and at the same time, it reduces to a minimum the transportation of materials between individual operations (Fig. 1).

It is considered in England that one of the most significant advances in the production of tin plate is the first continuous annealing unit at the Velindre Works, put into operation in 1958. During the initial period of operation the cost of the continuous annealing process is higher than annealing in the bell-type furnaces and the quality of the tin plate (by the Erichsen test) is somewhat lower.

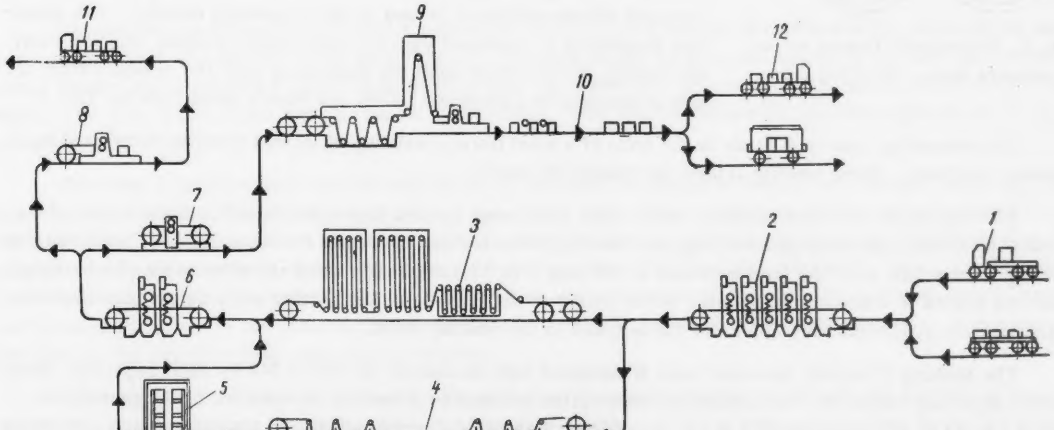

Fig. 1. Diagramatic layout of the Velindre Works; 1) pickled coils brought from the hot-rolling mills; 2) five-stand cold-rolling mill; 3) continuous annealing unit; 4) electrolytic cleaning unit; 5) bell furnace annealing; 6) two-stand finishing mill; 7) coil-preparation unit; 8) cutting unit; 9) electrolytic-tinning unit; 10) cutting and grading of tin plate; 11) loading of black plate; 12) loading of tin plate.

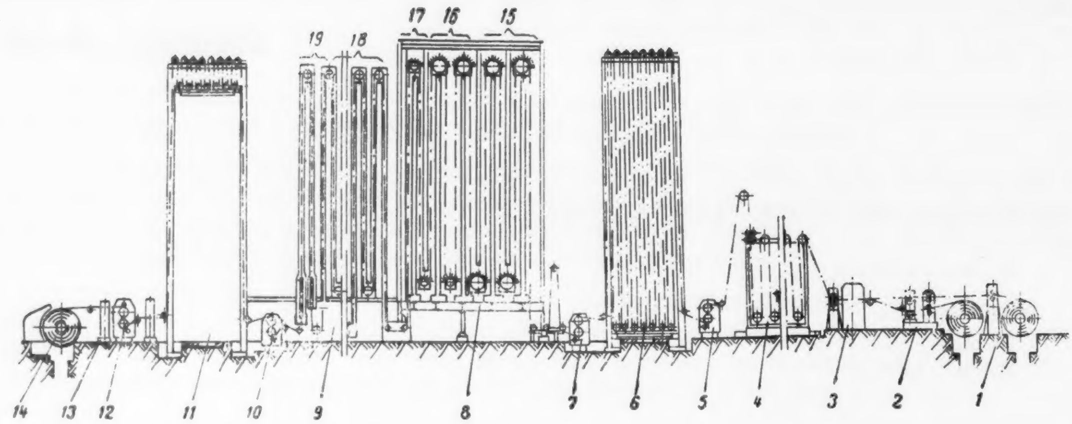

Fig. 2. Diagram of the continuous annealing unit at the Velindre Works. 1) Decoiling station; 2) double-cut shears; 3) welding machine; 4) cleaning unit; 5), 7), 10), driving rolls; 6), 11), pilers; 8) furnace section; 9) cooling section; 12) pulling station; 13) shears; 14) coiling station; 15) heating zone; 16) soaking zone; 17) slow cooling zone; 18) rapid cooling zone (the strip length is 215 m); 19) final air-cooling zone (the strip length is 27 m).

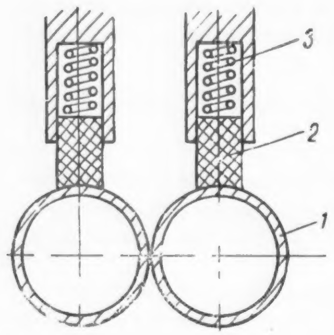

Fig. 3. Roller seal 1) steel roller; 2) asbestos brush; 3) spring.

Nevertheless, continuous annealing represents an advanced and promising process. It ensures a continuous annealing operation - the last operation in the production process of black plate - it reduces the duration of the process, and makes it possible to obtain a uniform steel structure. It is planned to anneal approximately 80% of the total tin-plate output by this method in the U.S.A. in 1965.

A general change to continuous annealing is planned in Great Britain. Figure 2 shows a diagram of the continuous annealing unit at the Velindre Works. At the front end, in addition to the ordinary equipment for uncoiling, cutting, and welding the ends of the coils, there is also an arrangement for chemical degreasing. A hot solution of caustic soda, sodium orthosilicate, and sodium carbonate is used as the degreasing solution. The chemical degreasing is combined with the mechanical brushing and hot-water-jet rinsing. At the outlet from the degreasing unit, the moisture from the strip is removed by rubberized rollers and finally dried with hot air.

The annealing furnace is made in the form of a steel tower consisting of welded sections, reinforced by brackets and bolts. Sheet asbestos is used for sealing the joints.

The strip to be annealed moves in loops, each loop being located in a separate cell. In the course of its thermal treatment, the strip passes through the heating zone, soaking zone, and the zones of slow, rapid, and final cooling. In the first zone the strip is heated to 732 deg C in 17.4 sec by gas-fired radiation tubes (the heating tubes are placed in each section over the whole height of the furnace). The heating temperature is controlled automatically by the quantity of air and gas supplied to the heating tubes.

The soaking (7 seconds duration) zone is equipped with an electric heater of 240 kw total capacity. Under normal operating conditions the electricity consumption amounts to 3 kw/ton. In the slow cooling zone, the strip is cooled to 426 deg C in 10.5 sec by air which is fed into the tubes mounted in the cell on both sides of the moving strip.

In the rapid-cooling zone the temperature of the strip is reduced to 120 deg C in 65 seconds, owing to fast heat removal by cold water which flows through special jackets. The strip forms 16 loops in this zone. At the outlet from the furnace the strip is blown with cold air and cooled to 65 deg. C.

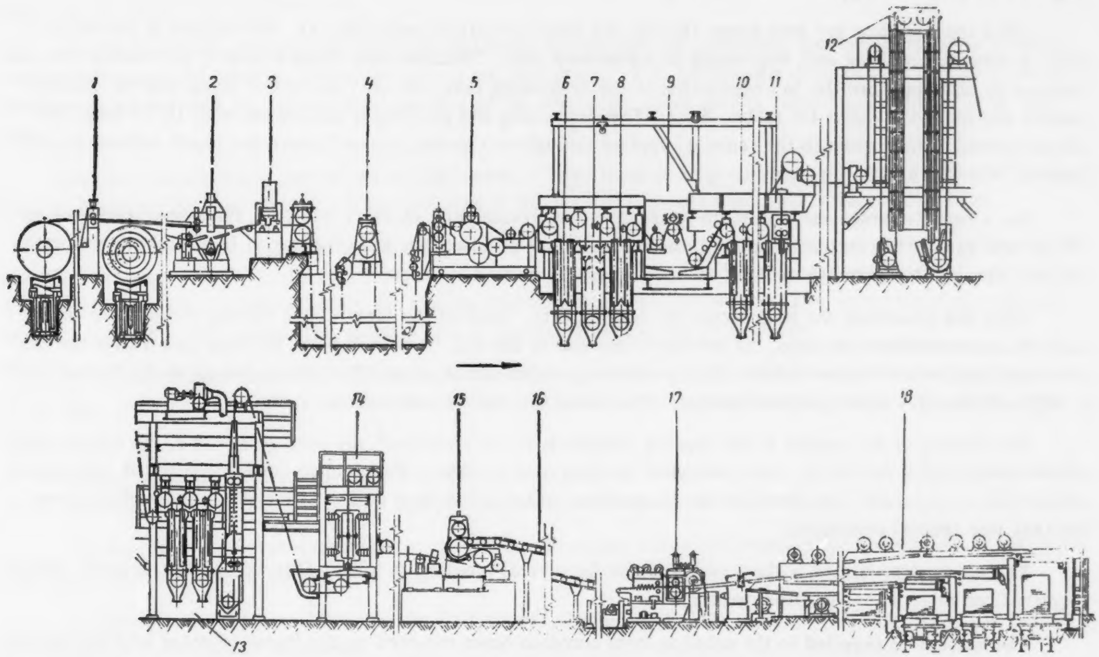

Fig. 4. The electrolytic tinning plant at the Velindre Works 1) decoiling unit (two decoilers); 2) double-cut shears; 3) welding machine; 4) looping pits; 5) driving unit; 6) degreasing tank; 7) rinsing tank; 8) pickling tank; 9) brushing and washing machine; 10) coating tanks (8 tanks); 11) picking-up tanks; 12) melting unit; 13) passivating unit; 14) electrolytic oiling machine; 15) stretching unit; 16) conveyer; 17) flying shears; 18) sorting and packing section.

For the prevention of the oxidization of the metal during the annealing, a protective gas consisting of 93-94% nitrogen and 7-6% hydrogen is charged into the furnace, the gas being completely free from oxygen and methane (the humidity of the gas is determined at a temperature below 40 deg C). The protective gas is charged into the lower part of each section.

To maintain an excess pressure of the protective gas (25 mm of water), the inlet and the outlet of the furnace are provided with special roller seals (Fig. 3). The strip passes between two rollers of 127 mm diameter; asbestos brushes are pressed by a spring against the rollers and constitute, as it were, the continuation of the furnace shell. The ends of the rollers are also sealed with brushes. This method ensures the required tightness of the furnace and minimizes gas leaks.

The plant is provided with special equipment to eliminate stoppages in case of the fracture of the strip in the furnace. On either side of the strip there are two closed plate chains resting on sprocket wheels mounted on the roll necks. The lower branch of the chain passes under the furnace. One of the sprocket wheels is driving, the other rotates freely on the roll necks. During normal operation the chain remains stationary. When the fractured end is noticed through a corresponding inspection window, the strip is attached to the chain which moves forward and takes the strip out of the furnace. Not more than five hours is lost when a breakdown occurs. A fracture of the strip occurs not more than once in three months.

The total length of the strip in the furnace, including the cooling section, is 370 m, the duration of the heat treatment is approximately 2 minutes, the normal speed of the strip is 180 m/min, and the maximum 210 m/min.

Apart from the continuous annealing, the electrolytic tinning machines are the most advanced units in the tin-plate shops. All six electrolytic tinning machines built in England (3 units at Velindre, 2 units at Trostre, and 1 unit at Ebbw Vale) operate with the use of sulfuric acid electrolytes containing 35 g/liter $SnSO_4$ (as tin), 50 g/liter phenolsulfonic acid, 50 g/liter of sulfuric acid, and some special additives in the amount of approximately 1 g/liter.

Decoilers receive 12-ton coils from the electrolytic unit by a special rewinding equipment on which the edges of the strip are tripped and defective places removed.

After the decoilers the strip passes through the usual operation cycle (Fig. 4). The surface of the black plate is prepared, starting with degreasing in a one-loop tank. Then the strip forms a loop in the rinsing tank and enters a pickling tank similar in construction to the degreasing tank, the only difference being that its internal surface and the lower roller are rubber lined. The degreasing and pickling is carried out with 15-20 amp/dm^2 direct current. The current to the tanks is supplied through two rollers, located above the liquid surface at a distance of 600-700 mm.

For a better contact and minimum losses of the degreasing and pickling solutions, the rubber-lined rollers are pressed against the current-supplying rollers. After the pickling, the strip is cleaned in a brushing and washing machine in which brushes made of Mexican grass "tampico" are used.

After this treatment the strip enters the coating bath. Each of the electrolytic tinning baths (there are usually 8) accommodates one loop. At the entry into and at the exit from each bath, the strip passes over the current-supplying bronze rollers and the tightly adjoining rubber-lined roller. The direct current to the bronze roller is supplied through copper-graphite brushes. The rollers are cooled with running water.

The density of the current in the tinning solution is 17-20 amp/dm^2, the voltage 12-15 v, the temperature of the electrolyte is 30-40° C, and the yield is equivalent to 98% of the electric current consumed. During the electrolysis a continuous circulation of the electrolyte, which is fed from below, takes place; it overflows from the tank into special containers.

The electrolyte is used without replacement for several months; it is then filtered and left to settle, which requires from three weeks to three months.

The current is supplied to the solution from common buses mounted on the frame together with the bronze rollers. The frame is built as a unit and it can be lifted when the strip has to be charged in, or when it fractures.

The tin anodes are smooth, made in the form of rods from pure tin, and are 1.5 meters long; they are slightly thinner in their lower part. Depending on the consumer's requirements, the tin plate can be made with 0.4-15μ thick coating. The thickness of the coating is controlled by the current density and the speed of the strip.

After the tinning, the strip passes through the pick-up tank where any remaining electrolyte is removed by the stream of distilled water. The diluted solution from the pick-up tank is then partially evaporated and added to the tinning tank.

At one of the electrolytic tinning machines at the Velindre Works, a tank is provided for the electrodeposition of iron on one side of the tinned strip, downstream of the pick-up tank if differential coating is required. Iron is deposited in a thin layer on one side (approximately 0.4-0.5μ), so that the two sides can be easily distinguished.

The finishing operations on the electrolytic tin plate consist of melting, passivation and oiling. The first operation is carried out by heating the strip with an electric current. The height of the loop during the melting is 7.5 meters. The current and the voltage are controlled automatically, depending on the thickness and the width of the strip as well as on its speed. After the melting, the strip is quenched in cold water.

After the quench bath, the strip is subjected to passivation at a current of 20 amp/dm^2 in a solution of sodium bichromate, alkali, and a wetting agent.

At the Ebbw Vale Works the strip is passivated chemically in a flowing stream. The strip is washed in hot water and dried with air.

The last finishing operation on the electrolytic tin is oiling. At the Velindre and Trostre Works, the stream is oiled in a high-voltage electric field (80-130 kv), and at the Ebbw Vale Works by a stream of emulsified cottonseed oil in water (two parts of oil per thousand parts of water). An oil fog is produced by blowing hot air through a layer of cottonseed oil (2 parts in a high-voltage chamber).

The tail end of the electrolytic tinning machine consists of flying shears for cutting the tin plate into sheets, and of equipment for the automatic sorting and packing of the sheets. The strip is delivered to the shears by 15-roll straightening machine; the sheet is cut in one revolution of the flying shears. It is cut to an accuracy of

± 0.35 mm. At the Velindre Works one machine has an additional coiler with a floating head on which the tin plate can be wound directly into coils.

All the machines are equipped with cobalt-isotope instruments for measuring the thickness of the coating and detecting any deficiencies before the strip is cut into sheets. The instruments operate with the use of photoelements; they are used for the automatic sorting of the sheets into three grades "Good", "Doubtful", and "Rejects."

Because the sorting is carried out at high speed, a large number of good sheets get mixed with the "rejects." Special machines for a second sorting are provided at the shop to separate these sheets from the rejects.

With the introduction of continuous annealing and electrolytic tinning machines, the whole operation cycle of tin production at the Velindre and Trostre Works constitutes a continuous process without any batch operations. The exception is the machines for hot-dip tinning of sheets at the Trostre Works. The whole tin-plate output is supplied mainly to the canned food industry and as packing material for other goods.

0.76 μ thick electrolytic tin, without paint coating is used for packing edible fats, confectionery, cocoa, dried eggs, etc. Tin plate of the same thickness, but with a paint coating, is used for canning fruits, juices, and beer.

Painted tin plate with 1.52 μ thick coating is in the greatest demand and is used for most foodstuffs as well as for packing pharmaceutical materials and photographic and various other chemicals.

The tin plate is processed into cans at special can factories which are separate from canned-food factories. The tin plate is painted at the can factories.

According to British specifications, the thickness of the tin plate varies from 0.14 to 0.4 mm. The greatest demand is for 0.25 mm tin plate.

Soviet Journals Available in Cover-to-Cover Translation

ABBREVIATION	RUSSIAN TITLE	TITLE OF TRANSLATION	PUBLISHER	TRANSLATION BEGAN Vol.	Issue	Year
AÉ	Atomnaya énergiya	Soviet Journal of Atomic Energy	Consultants Bureau	1	1	1956
Akust. zh.	Akusticheskii zhurnal	Soviet Physics – Acoustics	American Institute of Physics	1	1	1955
	Antibiotiki	Antibiotics	Consultants Bureau	4	1	1959
Astr(on). zh(urn).	Astronomicheskii zhurnal	Soviet Astronomy—AJ	American Institute of Physics	34	1	1957
Avto(mat). svarka	Avtomaticheskaya svarka	Automatic Welding	British Welding Research Association (London)		1	1959
	Avtomatika i Telemekhanika	Automation and Remote Control	Instrument Society of America	27	1	1956
	Biofizika	Biophysics	National Institutes of Health*		1	1957
	Biokhimiya	Biochemistry	Consultants Bureau	21	1	1956
Byull. éksp(erim). biol. i med.	Byulleten' éksperimental'noi biologii i meditsiny	Bulletin of Experimental Biology and Medicine	Consultants Bureau	41	1	1959
DAN (SSSR) Dokl(ady) AN SSSR	Doklady Akademii Nauk SSSR	The translation of this journal is published in sections, as follows:				
	Life Sciences	Doklady Biochemistry Section	American Institute of Biological Sciences	106	1	1956
	Life Sciences	Doklady Biological Sciences Sections (Includes: Anatomy, biophysics, cytology, ecology, embryology, endocrinology, evolutionary morphology, genetics, histology, hydrobiology microbiology, morphology, parasitology, physiology, zoology sections)	American Institute of Biological Sciences	112	1	1957
	Life Sciences	Doklady Botanical Sciences Sections (Includes: Botany, phytopathology, plant anatomy, plant ecology, plant embryology, plant physiology, plant morphology sections)	American Institute of Biological Sciences	112	1	1957
	Chemical Sciences	Proceedings of the Academy of Sciences of the USSR, Section: Chemical Technology	Consultants Bureau	106	1	1956
	Chemical Sciences	Proceedings of the Academy of Sciences of the USSR, Section: Chemistry	Consultants Bureau	106	1	1956
	Chemical Sciences	Proceedings of the Academy of Sciences of the USSR, Section: Physical Chemistry	Consultants Bureau	112	1	1957
	Earth Sciences	Doklady Earth Sciences Sections (Includes: Geochemistry, geology, geophysics, hydrogeology, mineralogy, paleontology, petrography, permafrost sections)	American Geological Institute	124	1	1959
	Earth Sciences	Proceedings of the Academy of Sciences of the USSR, Section: Geochemistry	Consultants Bureau	106-123	1 6	1957-1958
	Earth Sciences	Proceedings of the Academy of Sciences of the USSR, Sections: Geology	Consultants Bureau	106-123	1 6	1957-1958
	Mathematics	Doklady Soviet Mathematics	The American Mathematics Society	131	1	1961
	Physics	Soviet Physics—Doklady (Includes: Aerodynamics, astronomy, crystallography, cybernetics and control theory, electrical engineering, energetics, fluid mechanics, heat engineering, hydraulics, mathematical physics, mechanics, physics, technical physics, theory of elasticity sections)	American Institute of Physics	106	1	1956
	Physics	Proceedings of the Academy of Sciences of the USSR, Applied Physics Sections (does not include mathematical physics or physics sections)	Consultants Bureau	106-117	1	1956-1957
Derevoobrabat. prom-st'.	Derevoobrabatyvayushchaya promyshlennost'	Wood Processing Industry	Timber Development Association (London)		9	1959
	Élecktrosvyaz	Telecommunications	Massachusetts Institute of Technology*		1	1957
Éntom(ol). oboz(renie)	Éntomologicheskoe obozrenie	Entomological Review	American Institute of Biological Sciences	38	1	1959
Farmakol. (i) toksikol(ogiya)	Farmakologiya i toksikologiya	Pharmacology and Toxicology	Consultants Bureau	20	1	1957
FMM	Fizika metallov i metallovedenie	Physics of Metals and Metallography	Acta Metallurgica*	5	1	1957
Fiziol. zhurn. SSSR (im. Sechenova)	Fiziologicheskii zhurnal im. I. M. Sechenova	Sechenov Physiological Journal USSR	National Institutes of Health*		1	1957
Fiziol(ogiya) rast.	Fiziologiya rastenii	Plant Physiology	American Institute of Biological Sciences	4	1	1957
	Geokhimiya	Geochemistry	The Geochemical Society		1	1958
FTT	Fizika tverdogo tela	Soviet Physics—Solid State	American Institute of Physics	1	1	1959
Izmerit. tekh(nika)	Izmeritel'naya tekhnika	Measurement Techniques	Instrument Society of America		1	1959
Izv. AN SSSR, O(td). Kh(im). N(auk)	Izvestiya Akademii Nauk SSSR: Otdelenie khimicheskikh nauk	Bulletin of the Academy of Sciences of the USSR: Division of Chemical Sciences	Consultants Bureau		1	1952

continued

Izv. AN SSSR, O(td). T(ekhn). N(auk): Met(all). i top.	(see Met. i top.)					
Izv. AN SSSR Ser. fiz(ich).	Izvestiya Akademii Nauk SSSR: Seriya fizicheskaya	Bulletin of the Academy of Sciences of the USSR: Physical Series	Columbia Technical Translations		1	1954
Izv. AN SSSR Ser. geofiz.	Izvestiya Akademii Nauk SSSR: Seriya geofizicheskaya	Bulletin (Izvestiya) of the Academy of Sciences USSR: Geophysics Series	American Geophysical Union		1	1954
Izv. AN SSSR Ser. geol.	Izvestiya Akademii Nauk SSSR: Seriya geologicheskaya	Izvestiya of the Academy of Sciences of the USSR: Geologic Series	American Geological Institute		1	1958
Kauch. i rez.	Kauchuk i rezina	Soviet Rubber Technology	Research Association of British Rubber Manufacturers	18	1	1959
	Kinetika i kataliz	Kinetics and Catalysis	Consultants Bureau	1	3	1960
	Koks i khimiya	Coke and Chemistry USSR	Coal Tar Research Association (Leeds, England)		1	1958
Kolloidn. zh(urn).	Kolloidnyi zhurnal	Colloid Journal	Consultants Bureau	14	1	1952
	Kristallografiya	Soviet Physics – Crystallography	American Institute of Physics	2	1	1957
Metalov. i term. obrabot. metal.	Metallovedenie i termicheskaya obrabotka metallov	Metal Science and Heat Treatment of Metals	Acta Metallurgica	6	1	1958
	Metallurg	Metallurgist	Acta Metallurgica		1	1957
Met. i top.	Metallurgiya i topliva	Russian Metallurgy and Fuels	Eagle Technical Publications		1	1960
Mikrobiol.	Mikrobiologiya	Microbiology	American Institute of Biological Sciences	26	1	1957
OS	Optika i spektroskopiya	Optics and Spectroscopy	American Institute of Physics		6	1959
	Pochvovedenie	Soviet Soil Science	American Institute of Biological Sciences		1	1958
	Priborostroenie	Instrument Construction	British Scientific Instrument Research Association		1	1959
Pribory i tekhn. éks(perimenta)	Pribory i tekhnika éksperimenta	Instruments and Experimental Techniques	Instrument Society of America		1	1957
Prikl. matem. i mekh.	Prikladnaya matematika i mekhanika	Applied Mathematics and Mechanics	American Society of Mechanical Engineers		1	1958
PTÉ	(see Pribory i tekhn. éks.)					
	Problemy Severa	Problems of the North	National Research Council of Canada			
Radiotekh.	Radiotekhnika	Radio Engineering	Massachusetts Institute of Technology*	12	1	1957
Radiotekh. i élektronika	Radiotekhnika i élektronika	Radio Engineering and Electronics	Massachusetts Institute of Technology*	2	1	1957
	Stanki i instrument	Machines and Tooling	Production Engineering Research Assoc.		1	1959
	Stal'	Stal (In English)	Iron and Steel Institute		1	1959
Stek. i keram.	Steklo i keramika	Glass and Ceramics	Consultants Bureau	13	1	1956
Svaroch. proiz-vo	Svarochnoe proizvodstvo	Welding Production	British Welding Research Association		4	1959
Teor. veroyat. i prim.	Teoriya veroyatnostei i ee primenenie	Theory of Probability and Its Applications	Society for Industrial and Applied Mathematics		1	1956
Tsvet. Metally	Tsvetnye metally	Nonferrous Metals	Primary Sources		1	1960
UFN	Uspekhi fizicheskikh Nauk	Soviet Physics – Uspekhi (partial translation)	American Institute of Physics	66	1	1958
UKh	Uspekhi khimii	Russian Chemical Reviews	The Chemical Society (London)		1	1960
UMN	Uspekhi matematicheskikh nauk	Russian Mathematical Surveys	London Mathematical Society	15	1	1960
Usp. fiz. nauk	(see UFN)					
Usp. khim(ii)	(see UKh)					
Usp. matem. nauk	(see UMN)					
Usp. sovr. biol.	Uspekhi sovremennoi biologii	Russian Review of Biology	Oliver and Boyd		48	1959
Vest. mashinostroeniya	Vestnik mashinostroeniya	Russian Engineering Journal	Production Engineering Research Assoc.		4	1959
Vop. gem. i per. krovi	Voprosy gematologii i perelivaniya krovi	Problems of Hematology and Blood Transfusion	National Institutes of Health*		1	1957
Vop. onk.	Voprosy onkologii	Problems of Oncology	National Institutes of Health*		1	1957
Vop. virusol.	Voprosy virusologii	Problems of Virology	National Institutes of Health*		1	1957
Zav(odsk). lab(oratoriya)	Zavodskaya laboratoriya	Industrial Laboratory	Instrument Society of America	25	1	1959
ZhAKh Zh. anal(it). khimii	Zhurnal analiticheskoi khimii	Journal of Analytical Chemistry USSR	Consultants Bureau	7	1	1952
ZhETF / Zh. éksperim. i teor. fiz.	Zhurnal éksperimental'noi i theoreticheskoi fiziki	Soviet Physics–JETP	American Institute of Physics	28	1	1955
ZhFKh Zh. fiz. khimii	Zhurnal fizicheskoi khimii	Russian Journal of Physical Chemistry	The Chemical Society (London)		7	1959
ZhMÉI Zh(urn). mikrobiol. épidemiol. i immunobiol.	Zhurnal mikrobiologii, épidemiologii i immunobiologii	Journal of Microbiology, Epidemiology and Immunobiology	National Institutes of Health*		1	1957
ZhNKh / Zh(urn). neorgan(ich). khim(ii)	Zhurnal neorganicheskoi khimii	The Russian Journal of Inorganic Chemistry	The Chemical Society (London)		1	1959
ZhOKh / Zh(urn). obshch(ei) khimii	Zhurnal obshchei khimii	Journal of General Chemistry USSR	Consultants Bureau	19	1	1949
ZhPKh / Zh(urn). prikl. khimii	Zhurnal prikladnoi khimii	Journal of Applied Chemistry USSR	Consultants Bureau	23	1	1950
ZhSKh / Zh(urn). strukt. khimii	Zhurnal strukturnoi khimii	Journal of Structural Chemistry	Consultants Bureau	1	1	1960
ZhTF / Zh(urn). tekhn. fiz.	Zhurnal teknicheskoi fiziki	Soviet Physics–Technical Physics	American Institute of Physics	26	1	1956
Zh(urn). vyssh. nervn. deyat. (im. Pavlova)	Zhurnal vysshei nervnoi deyatel'nosti (im. I. P. Pavlova)	Pavlov Journal of Higher Nervous Activity	National Institutes of Health*		1	1956

*Sponsoring organization. Translation through 1960 issues is a publication of Pergamon Press.

SIGNIFICANCE OF ABBREVIATIONS MOST FREQUENTLY ENCOUNTERED IN SOVIET PERIODICALS

FIAN	Phys. Inst. Acad. Sci. USSR.
GDI	Water Power Inst.
GITI	State Sci.-Tech. Press
GITTL	State Tech. and Theor. Lit. Press
GONTI	State United Sci.-Tech. Press
Gosénergoizdat	State Power Engr. Press
Goskhimizdat	State Chem. Press
GOST	All-Union State Standard
GTTI	State Tech. and Theor. Lit. Press
IL	Foreign Lit. Press
ISN (Izd. Sov. Nauk)	Soviet Science Press
Izd. AN SSSR	Acad. Sci. USSR Press
Izd. MGU	Moscow State Univ. Press
LÉIIZhT	Leningrad Power Inst. of Railroad Engineering
LÉT	Leningrad Elec. Engr. School
LÉTI	Leningrad Electrotechnical Inst.
LÉTIIZhT	Leningrad Electrical Engineering Research Inst. of Railroad Engr.
Mashgiz	State Sci.-Tech. Press for Machine Construction Lit.
MÉP	Ministry of Electrotechnical Industry
MÉS	Ministry of Electrical Power Plants
MÉSÉP	Ministry of Electrical Power Plants and the Electrical Industry
MGU	Moscow State Univ.
MKhTi	Moscow Inst. Chem. Tech.
MOPI	Moscow Regional Pedagogical Inst.
MSP	Ministry of Industrial Construction
NII ZVUKSZAPIOI	Scientific Research Inst. of Sound Recording
NIKFI	Sci. Inst. of Modern Motion Picture Photography
ONTI	United Sci.-Tech. Press
OTI	Division of Technical Information
OTN	Div. Tech. Sci.
Stroiizdat	Construction Press
TOÉ	Association of Power Engineers
TsKTI	Central Research Inst. for Boilers and Turbines
TsNIÉL	Central Scientific Research Elec. Engr. Lab.
TsNIÉL-MÉS	Central Scientific Research Elec. Engr. Lab.-Ministry of Electric Power Plants
TsVTI	Central Office of Economic Information
UF	Ural Branch
VIÉSKh	All-Union Inst. of Rural Elec. Power Stations
VNIIM	All-Union Scientific Research Inst. of Meteorology
VNIIZhDT	All-Union Scientific Research Inst. of Railroad Engineering
VTI	All-Union Thermotech. Inst.
VZÉI	All-Union Power Correspondence Inst.

Note: Abbreviations not on this list and not explained in the translation have been transliterated, no further information about their significance being available to us – Publisher.